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Contents

EDITORIAL

This issue of *Phelsuma* carries a number of highly significant records. An account of the ecology and conservation of Aride island provides a useful background to this exceptional reserve and is followed by the remarkable record of robber crabs (*Birgus latro*) on the island. Only two individuals have been identified and the population is presumed to be small, why robber crabs are not more widespread in the granitic Seychelles islands and why their presence has only now been confirmed remain mysteries. It is tempting to suggest that the recent dramatic changes in sea temperatures have allowed their larval stages to survive in the waters of the Seychelles plateau, but this is purely speculative.

Other new records for the Seychelles fauna are given. The fact that these new records include large moths of a largely Malagasy origin may indicate that there have been recent waves of colonisation from that region, it seems unlikely that the largest moth in Seychelles would have been overlooked previously.

A particularly valuable record is the identification of the vector of the takamaka *Calophyllum inophyllum* wilt fungus. The study reported here identifies the endemic bark beetle *Cryphalus trypanus* as a vector of this species. The fact that this beetle is a Seychelles endemic is of note as this indicates that the fungus was imported into the islands in wood, rather than being carried by an alien beetle. A second point of interest is that this beetle has previously been recorded feeding on the endemic high-forest tree *Northea hornei*. Its presence in takamaka is surprising and at first would suggest a host shift. This may be misleading as Hugh Scott collected the beetle on Marianne in 1908, *N. hornei* has never been recorded on the island and Scott's record suggests that the beetle may have been in Marianne's takamaka forest. Perhaps *C. trypanus* infestation of takamaka is purely natural and it is the arrival of the fungus that represents a problem; we assume that to be unnatural, but where did it come from and how did it travel ?

J. Gerlach
Editor

CHAIRMAN'S REPORT

This past year has been one of consolidation and improvement for all our projects here on Silhouette Island. Our sole remaining project on Mahé, the Roche Caiman Bird Sanctuary, did not fare so well, but was given hope at the end of the year by enthusiastic moves proposed by one of our Council members.

The Silhouette Conservation Project has continue to produce more exciting records as we have increased the number of survey areas. Each site reveals something of interest highlighting Silhouette as the most important reservoir of biodiversity in the granitic Seychelles.

A major boost to the project came with funding for the renovation of an old building for use as an information centre and laboratory. At the time of going to press, work on the building was in the final stages and a formal opening is planned for June 1999. The centre will enable us to increase the amount of information on the natural history of the island available to visitors. The laboratory will not only give us the opportunity to work in a purpose-designed space but will be available to visiting scientists.

The Seychelles Giant Tortoise Conservation Project continued to be a source of great interest to visitors to the enclosures. The project is seen as an added attraction to the wonders of Silhouette that many natural history tours come to enjoy. In November we finally managed to arrange a lease with the owner of one of two *Dipsochelys arnoldi* females that were at the Auberge de Bougainville on Mahé. She is a good breeding age, but her small size as a result of years of near starvation may mean that she cannot reproduce within the period of the lease.

In February the project was the subject of a lecture given by Justin Gerlach at the Royal Geographical Society in London. Sir David Attenborough, the project's patron, introduced the lecture. We are very grateful for his support and this contribution which greatly helped in gathering together a very enthusiastic group of tortoise aficionados, old friends of Silhouette and future supporters.

The Seychelles Terrapin Conservation Project was assisted this year by funding from the U.S. Ambassador's Self-Help Fund. We were able to purchase the materials for the construction of a new secure enclosure and new tanks for the terrapins. As though a sign of approval from the *Pelusios subniger* terrapins, they produced 25 eggs. Most were not viable (see project report) but we hope that some will hatch.

Our publications have gone from strength to strength. This is the seventh volume of "*Phelsuma*" under the committed editorship of Justin Gerlach. "Birdwatch" has reached its 30th issue and we are grateful to all those dedicated contributors who make time in their busy lives to write informative articles for our readers. The U.S. Ambassador's Self-Help Fund has provided us with a new desktop publishing programme and a scanner this year. This equipment will make us more independent and enable us to produce more professional-looking publications.

Without the encouragement, financial support and help of the following organisations and individuals, our various projects would not have progressed so well:

Embassy of the United States of America - for equipment to enhance our publications and enclosures for the terrapin project

Prince Bernhard's Nature Trust - funding for constructing the information centre
Rick Watson - donation
Robert Lebenson - funding for laboratory furnishing and equipment
I.D.C. - premises and logistic support on Silhouette
Dr. J. Steinbacher and "Gefiederte Welt" - donation
Tom Johnson - fundraising on S.Y. "PanOrama"
Pool & Patel - for acting as our honorary auditors

We would also like to thank all those equally important supporters who have made smaller but significant donations over the year.

Kathy Young acted as our conservation volunteer for three months. Her hard work, dedication and cheerful disposition were greatly appreciated. She also found herself in charge of T-shirt sales at the R.G.S. lecture in February!

With the help of people like Kathy, our various donors, supporters and steadily increasing membership, we anticipate a greater role for the NPTS in the conservation of this very special area of the Indian Ocean.

R. Gerlach
Chairman

NPTS SCIENTIFIC COMMITTEE

During 1998 the Scientific Committee continued its involvement with refining survey methods for the Silhouette Conservation Project. Comments from members of the committee were used in the preparation of a proposal to the Whitley Conservation Awards for the restoration of the lowland forest of Silhouette. This application was unsuccessful but it is hoped that alternative sources of funding will be secured.

In early 1999 a proposal for the eradication of rats on selected islands was circulated by the Division of Environment of the Seychelles government. The views of committee members with experience of alien mammal eradication and those with relevant concerns were sought. Concerns with management of non-target species were communicated to the DoE who are taking account of these issues. The preparation of contingency plans in cooperation with the DoE and the Bird Forum is planned so that measures can be prepared before the eradication programme in 2000.

J. Gerlach

FREGATE ISLAND INVERTEBRATES

Since 1996 the Zoological Society of London (ZSL) has been providing conservation assistance for Fregate Island invertebrate species in a project initiated by The Nature Protection Trust of Seychelles. In 1996 an ex-situ captive breeding programme was set up for the Fregate beetle *Pulposipes herculeanus* Solier, 1848, giant millipede *Seychelleptus seychellarum* (Desjardins, 1834) and enid snail *Pachnodus fregatensis* Van Mol & Coppois,

1980 at ZSL's Invertebrate Conservation Unit (ICU) (see *Phelsuma* 5(1997)). Since then, much has happened with these endangered invertebrates and this article provides an update on how the programmes are progressing.

All these species are kept in a dedicated 'breeding room' in the Invertebrate Section at London Zoo which was until recently on show to the visiting public. A new building, the 'Web of Life' has just been completed focusing on invertebrates as an illustration of biodiversity. This new building also houses the ICU, and the Fregate invertebrates are soon to be moved to this new 'home'. They will be on show to the public in a mixed species exhibit, with associated graphics explaining the threats they face. The public will also be able to view a new 'breeding room' where the captive breeding programme animals are to be more closely managed.

Fregate beetles

47 wild caught adult beetles were brought to ZSL in 1996. Just under a half of the founder adults are still alive, giving an indication of longevity as these beetles are at least 3 years old now. We have had excellent breeding results with 63 F1 adults emerging over the last 18 months, and there are still many larvae in the soil. The present population stands at 81 individuals. The captive bred F1 generation is being kept separately from the parent beetles, to prevent cross generation breeding and investigate when sexual maturity is reached. An exciting new development has been the very recent finding of larvae which the F1 generation have produced. In order to gain accurate data on emergence, longevity and body size parameters the beetles have been marked so they can be individually identified. This has been done by gluing small numbered, coloured discs to the pronotum of the beetles, which does not adversely affect them in any way, but allows the progress of individuals to be followed. One area we are particularly keen to investigate is whether there is any significant size difference in the captive bred F1 generation, compared with the wild population. Results so far indicate that the F1 generation is slightly smaller, but more work needs to be done to validate this and investigate the effects of different husbandry methods.

Giant millipede

The last of the wild caught adult millipedes died towards the end of 1998. A preliminary investigation in the large soil and leaf litter tub where they were housed revealed approximately 800 larvae of varying sizes. At the time of writing the young were approx. 10cm long. These beautiful creatures are rarely seen as they spend most of the time buried in the soil coming out at night to feed. When the millipedes are moved to the ICU, a thorough inventory will be taken of the young stock as we sift meticulously through the soil.

Enid snail

This species has now been successfully bred at ZSL to the second (F2) generation. All the present stock results from one F1 generation animal which self fertilised (unfortunately there was a population crash early on in the programme due to a temperature increase in the room). As a result, our stock is now undoubtedly rather inbred. An injection of 'new blood' from wild caught snails would be extremely beneficial genetically to this population.

It has proved possible to keep and breed the above three species in captivity. We now intend to carry out more detailed research into their life-cycles which will expand the knowl-

edge of the species biology and hopefully help with future conservation efforts for these remarkable animals.

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ROCHE CAIMAN BIRD SANCTUARY

No monitoring of birds, plants or invertebrates has been undertaken during the past 12 months due to problems arising from damage to the sanctuary and a general inability of the Chairman to motivate members of the Trust to involve themselves with management of the sanctuary.

An attempt was made to create an area of open water within the central area of the sanctuary but the excavator became bogged down in the muddy substrate and had to be rescued. This upheaval occasioned further damage to the fence which was finally repaired in March.

A new approach to the management of the sanctuary is being tried by council member Jimmy Valentin. Help with rebuilding those sections of the fence that are still broken is under discussion with the Division of Environment.

R. Gerlach

SEYCHELLES GIANT TORTOISE CONSERVATION PROJECT

The Seychelles Giant Tortoise Conservation Project has continued its steady progress. After frequent matings the female *Dipsochelys hololissa* and *D. arnoldi* appeared to show signs of searching for nest sites. They were removed from their respective mates in April and kept together. At the same time, a prolonged drought developed during which the tortoises spent long periods sleeping. No further signs of imminent nesting were observed and the females were returned to their mates in December. Mating occurred immediately and on 8th July 1999 the first eggs were laid by 'Clio' the female *D. arnoldi* (see report in this issue of *Phelsuma*).

The project has had many visitors, mostly tourists visiting Silhouette but including a visit by Drs B. Devaux and F. Bonin of the French tortoise conservation organisation SOPTOM. An account of their visit was published in 'La Tortue'.

The project has made significant advances in publicity. In August a full taxonomic revision of the *Dipsochelys* giant tortoises was published in the journal of the IUCN Tortoise & Freshwater Turtle Specialist Group. This has been followed by other significant scientific papers. In February 1999, Dr. J. Gerlach presented a lecture on the project at the Royal Geographical Society. This was introduced by Sir David Attenborough, the project's patron. His continued support and involvement in this project is greatly appreciated.

In October negotiation with the Auberge de Bougainville hotel on Mahé resulted in partial success and one of the two female *D. arnoldi* was leased to the project for a period of 5 years. The health of the Bougainville tortoises is so poor that full recovery and breeding may not be possible, but all attempts will be made to overcome these problems.

We continue to work for the release of the other female and an improvement in the prospects of the other Bougainville tortoises. The Seychelles government has expressed its support for this endeavour.

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J. Gerlach

SEYCHELLES TERRAPIN CONSERVATION PROJECT

During 1998 the U.S. Ambassador's Self-Help Fund agreed to fund the construction of new enclosures for the terrapin project. These will be completed during 1999. The existing temporary enclosures are not entirely satisfactory from a management perspective. Despite this the first captive breeding of *Pelusios subniger parietalis* was recorded in December. Unfortunately the available nesting areas appear to be unsuitable and all eggs have been laid in the water. Consequently only 1 of the 26 eggs was viable and this was destroyed by a rat. We anticipate that the new enclosures will allow the next breeding season to be successful for both species.

J. Gerlach

SILHOUETTE CONSERVATION PROJECT

The main development during 1998 was the start of renovation of a ruined building as an information centre with financial support from the Prince Bernhard's Nature Trust. The Silhouette Conservation Project information centre was completed in early 1999. This building will act as a focus for our educational and informative projects on Silhouette. It will also house our reference collections of animals and plants and contains a laboratory area.

Throughout the year the spread of takamaka wilt was monitored around the island. It has reached most coastal areas on the east side of the island, with isolated patches of infection on the western side. The most seriously affected area is Baie Cipailles where virtually all the beach-crest trees are dead. Beach erosion at this site is also severe. Monitoring of invasive plants has continued and control plans are being developed in a plan to restore degraded sites. Surveys of different parts of the island have revealed many interesting records. Important additions to the Silhouette species list have been made in all areas, including the

inhabited area of La Passe.

The 1998/9 hawksbill turtle nesting season was an improvement on the previous year, although the 21 emergences and 9 nests recorded is low in comparison to many other islands. This is still a notable population for the larger granitic islands.

J. Gerlach

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Swiftlets on islands: genetics and phylogeny of the Seychelles and Mascarene swiftlets

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Abstract: Populations on islands are isolated from mainland populations and are thus expected to diverge and speciate from mainland relatives. We investigated the phylogenetic position and taxonomic rank of the Seychelles and Mascarene swiftlets using nuclear (fibrinogen intron 7) and mitochondrial (cytochrome *b*) DNA sequences. Both sequences recovered a placement for these two swiftlets within a group of other echolocating swiftlets (*Aerodramus*). This agrees with previous results based on limited sequences and confirms a split in swiftlets between echolocating (*Aerodramus*) and non-echolocating species (*Collocalia*). The Seychelles and Mascarene swiftlets are 1.0% divergent in cytochrome *b* sequences suggesting they have been isolated for 500,000 years and merit species status as *Aerodramus elaphrus* and *Aerodramus francicus*. The distinctiveness of *Aerodramus elaphrus* and *Aerodramus francicus* emphasizes the need to develop conservation strategies for both of these species.

Key Words: *Aerodramus francicus*, *Aerodramus elaphrus*, Apodidae, cytochrome *b*, fibrinogen intron 7, echolocation

Island populations generally have small population sizes and are therefore often of conservation concern. Island populations are often genetically distinct from related mainland populations, which emphasizes the importance of preserving them. An important component of establishing priorities for conservation is the level of taxonomic distinctiveness of island populations, i.e. whether they are species, subspecies, or lack any appreciable differentiation from mainland relatives. Here we investigate these issues for two island bird species: the Seychelles swiftlet (*Aerodramus elaphrus* [Gmelin, 1789]) and Mascarene swiftlet (*A. francicus* [Oberholser, 1906]), which are endemic to the Seychelles and Mascarenes, respectively.

Swiftlets are small-bodied representatives of the family Apodidae. Members of the genus *Aerodramus* nest in caves and navigate using a crude form of echolocation (Chantler & Driessens 1995; Lee *et al.* 1996). Among swiftlets, which are distributed throughout Australasia and the South Pacific, *A. elaphrus* and *A. francicus* have the westernmost distribution and represent a biogeographic anomaly because no other species of swiftlet occurs within 2000 kilometres. The taxonomic status of these two species has varied among workers. Some authors place all swiftlets in the genus *Collocalia* (Gaymer *et al.* 1969; Chantler & Driessens 1995) while others separate the echolocating swiftlets into the genus *Aerodramus*, thus recognizing two major swiftlet genera (Lee *et al.* 1996). The species status of the Seychelles and Mascarene swiftlets has been questioned by some workers who consider them both subspecies of *A. francicus* (Gaymer *et al.* 1969; Penny 1974). Others separate them

into distinct species (Cheke 1987; Chantler & Driessens 1995; Lee *et al.* 1996). Lee *et al.* (1996) presented evidence from mitochondrial DNA sequences (cytochrome *b*) that *Aerodramus* and *Collocalia* are distinct genera and that the Seychelles and Mascarene swiftlets are genetically divergent species. Clayton *et al.* (1996) showed that the two species also have distinct subspecies of chewing lice (*Dennyus*), further supporting the distinctiveness of the host species. The goal of this study is to expand the genetic evidence from DNA sequences as a further aid to proper classification of the Seychelles and Mascarene swiftlets.

Methods

We extracted and amplified DNA from tissues of three individuals of *Aerodramus elaphrus* and two individuals of *Aerodramus francicus* according to the protocol of Johnson & Clayton (in review). We also extracted DNA from representatives of twelve other swift and swiftlet species including echolocating and non-echolocating species. Using PCR, we amplified both the mitochondrial cytochrome *b* gene and the nuclear ß-fibrinogen intron 7 gene for these samples. We sequenced these PCR products and aligned them using the methods described in Johnson & Clayton (in review). We constructed phylogenies using parsimony and PAUP* (Swofford 1998) and performed bootstrap analyses (Felsenstein 1985). We also compared genetic distances between species to estimate the timescale of speciation in swiftlets.

Results

For the mitochondrial cytochrome *b* gene (1037 base pairs), *Aerodramus elaphrus* and *A. francicus* show 1.0% sequence divergence. All individuals of each species cluster together to the exclusion of samples from other species, making each species monophyletic for mitochondrial DNA (Fig. 1). In contrast to the relatively large divergences between *A. elaphrus* and *A. francicus*, sequences among individuals within each species are identical (0.0%). These two species fall within a monophyletic clade of echolocating swiftlets (Fig. 1). *A. elaphrus* and *A. francicus* are each other's nearest relative and the closest relatives (included in this study) to these two species are *A. salanganus* (Streubel, 1848) and *A. spodiopygius* (Peale, 1848), from which *A. elaphrus* and *A. francicus* differ by 2.2 - 2.5%. The cytochrome *b* sequence data support a deep split between echolocating (*Aerodramus* spp.) and non-echolocating (*Collocalia* spp.) swiftlets with 98% confidence in bootstrap replicates (Fig. 1).

These results are also supported by sequences from a nuclear gene for several swiftlet species. A phylogeny derived from fibrinogen intron 7 sequences (920 base pairs) confirms the deep split between *Aerodramus* and *Collocalia* (unpublished data). The nuclear phylogeny also supports the position of *A. elaphrus* and *A. francicus* as each other's nearest living relatives, that are in turn most closely related to *A. salanganus* and *A. spodiopygius*.

Discussion

DNA sequence data can resolve a phylogeny for a group of species, aid in determining species' boundaries, and provide an estimate of the timing of speciation events. Sequence data from independently sorting mitochondrial (cytochrome *b*) and nuclear (fibrino-

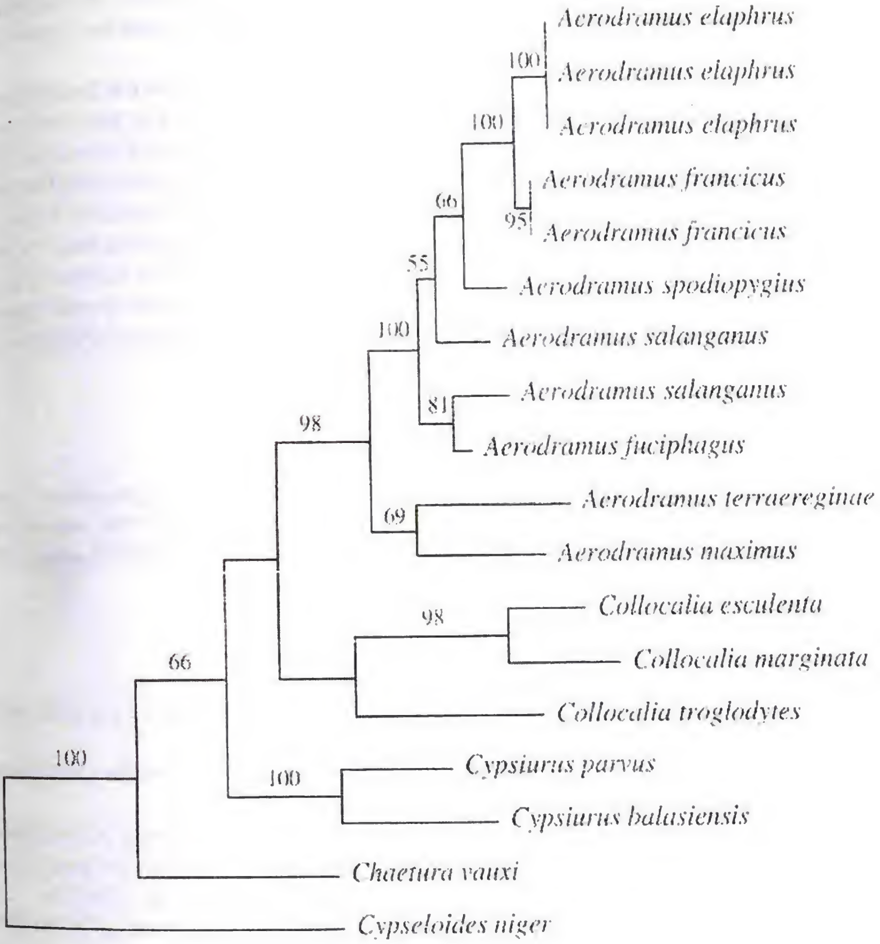

Fig. 1. Phylogeny for swiftlets (*Aerodramus* and *Collocalia*) derived from unordered parsimony of cytochrome *b* sequences, with three genera of swifts (*Cypsiurus*, *Chaetura* and *Cypseloides*) as outgroups. Only *Aerodramus* spp. are capable of echolocation. Branch lengths are proportional to reconstructed changes. Numbers on branches indicate bootstrap support from 1000 replicates. Unlabelled nodes received less than 50% bootstrap support.

gen intron 7) genes and swiftlets supports a pronounced split between the echolocating and non-echolocating species, consistent with the results of Lee *et al.* (1996) based on a shorter cytochrome *b* sequence. Thus, the phylogeny derived from these DNA sequences supports the recognition of *Aerodramus* and *Collocalia* as distinct genera of swiftlets. Two island swiftlets of conservation concern, the Seychelles swiftlet (*Aerodramus elaphrus*) and Mascarene swiftlet (*Aerodramus francicus*), fall within the genus *Aerodramus*, again confirming the results of Lee *et al.* (1996).

Sequences from the cytochrome *b* gene indicate that swiftlets from the Seychelles are identical and 1.0% divergent from swiftlets from Mauritius, which are in turn identical to other individuals on Mauritius. Using a molecular clock calibration for mitochondrial DNA of 2% per million years (Klicka & Zink 1997), we estimate that the Seychelles and Mascarene swiftlets have been isolated from each other for approximately 500,000 years with no gene flow. In addition, we estimate that these island species have been isolated from other swiftlets for approximately one million years, based on the genetic distance to their nearest relatives but we are not able to determine which island was colonized first. Our data strongly support recognition of the Seychelles and Mascarene swiftlets as distinct species, highlighting the need for conservation efforts directed at both of these unique species.

Acknowledgements

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The ecology of western Indian Ocean carnivorous land snails

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Abstract: The carnivorous snails of the western Indian Ocean are discussed in terms of their predatory behav and ecological relationships with their prey. Data are presented for the introduced *Euglandina ro* (Oleacinidae), *Gonaxis quadrilateralis* (Streptaxidae) and the native streptaxids *Edentulina dussum*, *Imperturbatia constans*, *Careoradula perelegans* and *Gulella poutrini*.

Key words: Gastropoda; Mollusca; Oleacinidae; predation; Streptaxidae

Introduction

The western Indian Ocean islands support exceptionally diverse and abundant ende radiations of carnivorous land snails (Bruggen 1967; Gerlach & Bruggen 1999). In additio small number of alien species have been introduced, either accidentally (*Gulella bicolor* (Hutt 1834)) or deliberately during biological control programmes (*Gonaxis quadrilateralis* (Prest 1910) and *Euglandina rosea* (Férussac, 1821). With both native and alien carnivores formi a significant proportion of the molluscan fauna it would be expected that these snails wo have a significant role in the region's ecology. There is only one published account of a ecological aspect of this fauna (Gerlach & Bruggen 1999), this details adaptations to carr feeding in the Seychelles streptaxid *Careoradula perelegans* (Martens, 1898). A study of ecology of the oleacinid *E. rosea* (Gerlach 1994) included data from Seychelles and Mascarenes and presented brief studies of the Mauritian streptaxid *Gulella poutrini* (Germa The present paper summarises available data for carnivorous snails of Seychelles and Mauriti

Methods

Carnivorous snails of Seychelles have been studied in the field continuously sin 1986. Field data for Mauritius and Réunion are derived from surveys carried out in 199 During field studies molluscs have been collected from a wide range of sites by hand searchi sieving and Winkler extraction. In most sites 10 haphazardly located 1m^2 quadrats have be used to estimate population densities.

The behaviour of the different species was studied in laboratory conditions. The larg streptaxid species from Seychelles, *Edentulina dussumieri* (Dufo, 1840), and the common small species, *Imperturbatia constans* (Martens, 1898), were used in feeding trials as was t commonest Mauritian species *Gulella poutrini*. In addition the alien species *Gona quadrilateralis* and the oleacidnid *Euglandina rosea* were studied. These were kept in individ plastic boxes measuring 18×10×6cm and kept damp. Lighting was on a fixed 12:12 ho light:dark cycle. Any individuals that were not being used in experiments were provided w suitably sized prey ad libitum. Prey were either wild collected from gardens (Helicidae) captive bred (Subulinidae and *Liardeita* spp.).

Prey species were maintained under the same conditions but using a variety of contai

zes; prey were not kept individually. Decomposing leaves were fed to herbivorous
pecies and small subulinids to carnivorous species.

Results

Morphology

Dissections of specimens in this study showed that the digestive anatomy of *E. rosea* exhibits several specialisations for carnivory. The buccal mass is contained within an extensible rostrum allowing the radula to be projected beyond the mouth and into the prey. The radula is adapted to carnivory by its large size and the specialisation of the teeth into elongated cones. The salivary glands are large and the intestine short, features that in other molluscs have been suggested to be adaptations to carnivory (Tillier 1989). An elastic crop is present, which stores the food mass prior to digestion (pers. obs.). In association with this the digestive gland (hepatopancreas) is large. The chemosensory lips at the front of the mouth are also specialised for predatory behaviour. They are greatly elongated, maximising the area they cover when used in detecting mucus trails deposited on the substrate by their prey (Cook 1985). These lips are also present in other carnivorous families of mollusc (Watson 1934; Gerlach 1994). Of the streptaxids studied here they are only apparent in *Edentulina dussumieri*

Predatory behaviour

Previous studies have defined discrete categories of feeding behaviours in *Euglandina rosea* (Cook 1983, 1989 a&b). These are summarised in Fig. 1. The behavioural sequences are notably different between the oleacinids and the streptaxids. Whilst *E. rosea* behaves as a generalist predator attacking all items identified as prey (including streptaxids), the streptaxids were more selective. This selectivity, expressed as a tendency to attack only relatively small prey that were either inactive or moving away, may be largely a consequence of specific size differences. In this respect it is worth noting that the smallest streptaxid observed (*Imperturbatia constans*) would only attack very small prey from behind, the larger species (*Gulella poutrini* and *Edentulina dussumieri*) would attack larger prey moving nearby but avoided prey heading towards the predator, whilst the largest (*Gonaxis quadrilateralis)* would attempt to attack all prey. Thus these behavioural differences may be expressed only as a consequence of size differences; the larger streptaxid species may be equally as effective predators as the oleacinid *Euglandina* species. If larger taxa are highly aggressive predators, the largest streptaxids may be able to consume smaller individuals of *E. rosea*. The extreme rarity of the larger streptaxids means that relevant data are not available but the presence of a subadult shell of *E. rosea* in the vicinity of a population of the large Mauritian streptaxid *Gonodomus pagodus* may possibly represent the outcome of one such interaction.

In *Edentulina dussumieri* no attempt was made to restrain prey during attack and if the first strike was not successful the prey always escaped. Pursuit was not attempted. In four cases of predation on *Liardetia sculpta* prey was consumed whole.

Predation by *G. poutrini* was found to be simple, involving a strike at the prey shortly after contact (on average 6.6 seconds). The *Omphalatropis* spp. responded by retracting into the shell on all occasions when attacked, blocking the aperture with the

operculum. Once the prey had retracted the predator was unable to penetrate the operculum. *G. poutrini* consume *Omphalatropis* when they are able to cause serious physical damage with their first strike, the limited experimental data suggest that successful strikes occur on fewer than 20% of occasions. In a natural environment where the complex structure of the leaf litter may impede movement in some directions a higher success rate may be possible.

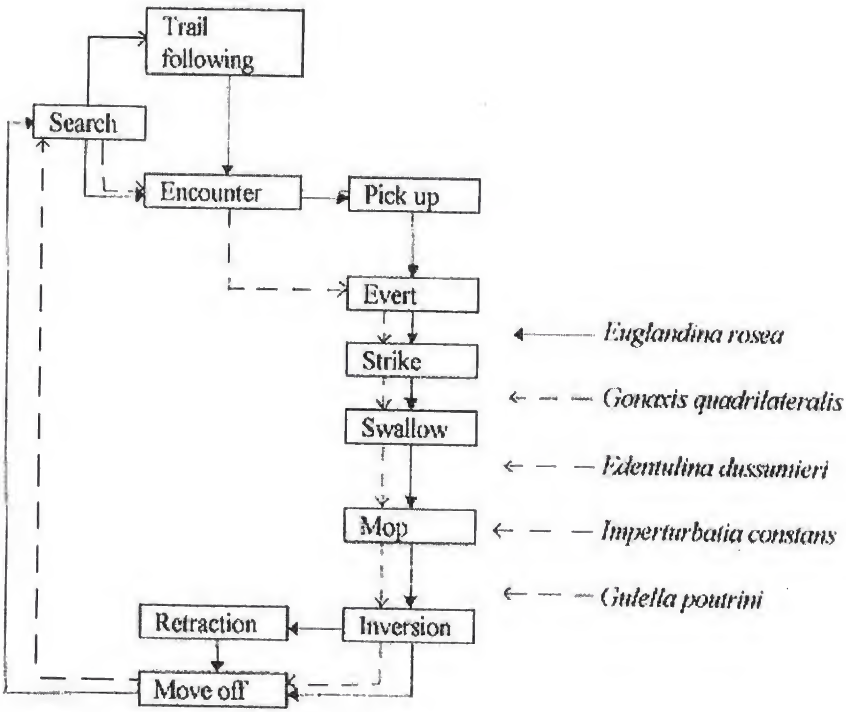

Fig. 1. Predatory behaviour in carnivorous snails.

Diet

Euglandina rosea preys exclusively on molluscs (Gerlach 1994). The diet of *Euglandina rosea* is known to include a wide variety of mollusc species. Studies prior to and during its use in biological control concentrated on the question of whether or not it would prey on *A. fulica* (Mead 1961; Muragaki & Deguchi 1987). In addition a wide range of pantropical species have been recorded as prey (Pilsbry 1948; Cook 1983, 1989a; Tillier & Clarke 1983; Clarke *et al.* 1984; Kinzie 1992; Lee pers. comm.). It has been reported that 83% of *E. rosea* dissected in Mauritius contain the remains of indigenous molluscs (Griffiths 1987); the detailed data of dietary analysis in the Mascarenes suggest that *E. rosea* is a generalist mollusc predator preferring small terrestrial prey species (Griffiths *et al.* 1993). It is also reported to be rarely cannibalistic (Gerlach 1994).

Feeding trials for *Edentulina dussumieri* demonstrate that it preys upon the following molluscs (maximum sizes of consumed prey are given in parentheses): *Pachnodus niger×velutinus* (7.8×6.7mm), *Achatina* spp. (8.7×5.8mm), Subulinidae (4.9×1.9mm), *Liardetia sculpta* (2.6×2.8mm) and *Leptichnoides verdcourti* (12mm long). *Helicina theobaldiana* were not attacked (10 trials).In the field predation was observed on *Pachnodus kantilali* (juvenile), *Leptichnoides verdcourti* and, on one occasion, on a fully grown nemertine worm (*Geonemertes pelaensis*). In the latter observation the nemertine (approximately 100mm in length) was being swallowed whole from the anterior end, peristaltic movements of the worm's body were detectable but there were no obvious responses to the predation. Two other nemertines were moving away from the site rapidly (Gerlach 1998). In addition *E. dussumieri* was frequently observed feeding on resin flowing out of the leaf blades of palm species (*Nephrosperma vanhouettana* and *Phoenicophorium borsigianum*).

Imperturbatia constans attacked and consumed *Liardetia sculpta* below 1.9mm in diameter. These were all investigated prior to attack, which would only occur if the prey was encountered from behind; head contact led to avoidance of the prey. None of the four prey consumed were swallowed whole. No larger prey were consumed and no field observations of predation were made

Gulella poutrini consumed. *Liardetia sculpta, Omphalatropis expansilabris, O. rubens, O. desjardinisi* and juvenile *Macrochlamys indica*. *Meghimatium bilineatum* was not eaten. Although the range and numbers of prey offered was insufficient to demonstrate any significant preferences the initial feeding trial does show that *G. poutrini* is able to prey upon smaller molluscs, including the operculate *Omphalatropis* spp.

Trail following behaviour

As the following of prey mucus trails is a significant component of the predatory behaviour of *Euglandina rosea* (Cook 1985) this was investigated in order to determine if any preferences were being expressed in hunting and whether or not streptaxids exhibit the same behaviour.

Predator preferences for specific prey were studied by comparison of the frequency of predators following trails left by different prey species. This was carried out by allowing prey ('markers') free movement on a sheet of squared paper (squares measuring 4×4mm) and recording which squares were crossed (squares labeled by numerical and alphabetical coordinates). The predator ('follower') was subsequently placed near the trail and also allowed

free movement, the squares it crossed were also recorded. Trail following was determined a having occurred when trails overlapped for at least 5 consecutive squares. For a trial to t recorded trails must have crossed at least once. The frequency of overlap in the absence trail following was determined by using the same method as above for two 'followe individuals of different herbivorous species, *Helix aspersa* and *Cepaea nemoralis*, (eliminatin trail following for predation or for mating purposes as the two individuals were not congeneric This allowed comparison of the frequency and significance of trail following for each pre species.

The effects of size differences on the frequency of trail following were investigate by using a series of artificial trails. These were formed by allowing one individual *Achatin fulica* to move over a sheet of paper in which the form of a linear template of a specific widt had been cut to form straight trails with precisely controlled widths, all with identical chemic cues (due to their all being laid by the same 'marker' individual). A 'follower' predator wa allowed free movement near the trails, investigative behaviour and direct turns onto the tra were noted once the trail had been contacted. Each trial was repeated 10 times, the sam marker and two different followers being used on each trail. The same followers were use for all trail sizes to ensure comparability of results. In all cases illumination was overhea and uniform, eliminating any lighting influence on the direction taken by the follower.

The data on trail width show that the proportion of trails investigated and followe increases with increasing width (Fig 2.). The regression slopes are not significantly differen and the two data sets have a partial correlation coefficient of 0.893 (P=0.001), showing tha trail investigation and following are dependent on trail width.

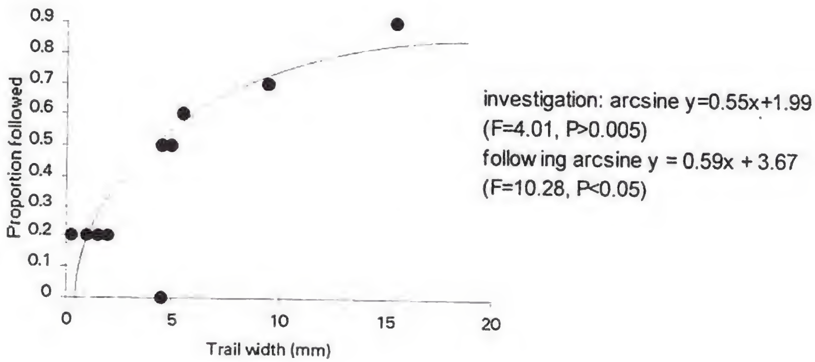

Fig. 2. The effect of trail width on trail following frequency

The sensory lips used in trail following cover approximately 15mm when fully extended (a greater area is covered in searching when the head is moved from side to side but little head movement occurs during following) beyond a trail width corresponding to this 15mm no discrimination would be expected to occur. In accordance with this 100% of trails are followed at a width of 16mm, no further increase is possible so the leveling out of the relationship does occur as expected due simply to the area covered by the sensory appendages of *E. rosea*.

Comparing the data for following trails of different species from the trials described above demonstrates that there is no clear preference for any species (the range of expectations given are calculated from the standard error of ±0.11 of the slope of the above regression):

In *Edentulina dussumieri* none of the species tested was followed more frequently than the random non-predatory model predicts. This shows that trail following is not a component of predatory behaviour in *E. dussumieri*. In this context it is worth noting that although there are extensions to the lips in *Edentulina dussumieri* these are not as pronounced as in *E. rosea*, and are presumably of limited use as chemoreceptors. None of the other streptaxid species encountered in the field localities possessed significantly elongated lips, suggesting that their trail following ability was no more developed than that investigated above. Absence of trail following was also demonstrated in *Gonaxis quadrilateralis*. The primary mode of predation in streptaxids would thus appear to be essentially random search.

For *Euglandina rosea* the data demonstrate that there is no expression of species preference in trail following that is not explicable solely by size variation, with the exception of the slug *Meghimatium bilineatum* which is followed less frequently than would be expected due to the production of a copious white mucus on provocation. The mucus caused *E. rosea* to move away in all trials of the slug and of palatable prey artificially coated with the mucus. This presumably distasteful mucus would be expected to be detectable in the mucus trail left during locomotion. It has been hypothesised (Cook 1985, 1989a) that avoidance of such mucus accounts for the low frequency of trail following recorded in the case of the philomycid slug *Philomycus carolinianus*, an explanation which is probably also valid for the confamiliar *M. bilineatum*.

Table 1. Number of trails of different species followed (10 trials)

Predator	Species	trail width (mm)	followed	expected
Euglandina rosea				
	Helicina theobaldiana	1	2	1.6-1.8
	Tropidophora pulchra	5	3	3.3-4.4
	Omphalatropis rubens	3	3	2.5-3.1
	Vaginula seychellensis	10	8	5.4-10
	Edentulina dussumieri	5	4	3.3-4.4
	Stylodonta unidentata	10	7	5.4-10
	Macrochlamys indica	5	4	3.3-4.4
	Leptichnoides verdcourti	3	3	2.5-3.1
	Meghimatium bilineatum	3	1	2.5-3.1
Edentulina dussumieri			**Mean overlap**	**Random overlap**
	Helicina theobaldiana		1	1.8
	Stylodonta unidentata		10	2.3
	Subulinidae		2	2.3
	Leptichnoides verdcourti		3	1.7

Selection

The influence of prey size on predation efficiency was studied by feeding tria using prey lacking chemical or mechanical defences (*Helix aspersa*) (measuring 5-35mr and juvenile Subulinidae (1.2-5mm long). The results are shown in Table 2.

Speeds of movement

The speeds of a variety of prey species were compared to those of hatchling, juveni and adult predators to determine whether rapid locomotion was an effective anti-predato defence in some species. Speed was compared by placing an individual of each species on sheet of squared paper (4×4mm squares) and recording the time taken to cover 30 square (120mm). For *E. rosea* a prey trail was provided to induce predatory behaviour, the pre were periodically disturbed from behind with the tip of a pair of forceps to induce avoidanc behaviour. The followers were fed 2 small prey in the 24 hours prior to the trial, the pre number resulting in the maximum speed. By these means it was ensured that hunting an escaping speeds were being recorded. 10 trials were used for each taxon.

Table 2. Size effects

Species	**Percentage of prey killed from each size group (mm), 10 trials**						
	1-5	**6-10**	**11-15**	**16-20**	**21-25**	**26-30**	**31-35**
Euglandina rosea	62	100	100	80	60	40	20
Gonaxis quadrilateralis	80	50	20	0	0	0	0
Edentulina dussumieri	80	30	0	0	0	0	0
Imperturbatia constans	60	0	0	0	0	0	0
Gulella poutrini	100	0	0	0	0	0	0

Table 3. Analysis of predator and prey speeds (one-tailed t-test, without assumin homoscedasticity: * = P<0.05; ** = P<0.005; ***=P<0.001)

Taxon	**Speed (mm/s)**	**t value of predation** *Euglandina* (2.177)	*Edentulina* (0.792)	*Gulella* (0.533)
Euglandina rosea - juvenile	1.407	4.88 ***	-8.50 ***	-14.79 ***
hatchling	0.443	7.73 ***	2.55 *	3.01 **
Achatina fulica <20mm	0.670	6.85 ***	1.63	-2.99 **
>20mm	1.240	3.47 **	-6.80 ***	-8.93 ***
Edentulina dussumieri	0.792	9.46 ***	-	-3.42 **
Gulella poutrini	0.532	11.45 ***	2.10	-
Stylodonta unidentata	0.487	8.69 ***	4.06 ***	0.61
Liardetia sculpta	0.211	14.31 ***	9.10 ***	5.56 ***
Macrochlamys indica	1.718	3.13 **	-10.80 ***	-15.37 ***
Leptichnoides verdcourti	3.112	2.78 *	-17.38 ***	-18.23 ***
Deroceras laevis	2.937	2.31 *	-15.10 ***	-16.21 ***
Meghimatium bilineatum	0.772	9.81 ***	-0.33	-3.40 **
Omphalatropis rubens	1.057	7.89 ***	-5.01***	-7.72 ***
Pachnodus kantilali	1.719	3.11 **	-11.00 ***	-11.98 ***
Pachnodus niger×velutinus	1.817	3.22 **	-11.23 ***	-12.31 ***
Bradybaena similaris	1.352	5.92 ***	-7.94 ***	-13.22 ***

Only *Deroceras laevis* and *Leptichnoides verdcourti* move significantly faster than adult *Euglandina rosea* (Table 3) whilst the mean speed of most species is significantly higher than that of the streptaxids, which would only be able to catch very small prey (such as *Liardetia sculpta*) or (for *Edentulina dussumieri*) the slow moving *Achatina fulica* and *Stylodonta unidentata* if pursuit was attempted. The observation that unsuccessful attacks were not followed by any attempt at pursuit is in accordance with these data.

Prey density

In order to obtain more representative data, density effects were studied using the small prey size class which occurs at densities of 0-48.5m^{-2}. Predator efficiency at different densities and with different depths of leaf litter was studied using one predator in a 0.25m^2 container. Small prey (*Liardetia sculpta* and Subulinidae) were supplied at densities of 4, 8, 12, 16 and 20m^{-2} (corresponding to 1, 2, 3, 4 and 5 prey), which encompasses the natural density range. After a 24 hour period the number of prey remaining was recorded. The predators used had been fed only two small prey during the previous 48 hours to maintain them at a consistent hunger level. Leaf litter depths used were 1 and 4cm. Each experimental block was replicated five times.

Predation efficiency of adult *E. rosea* is influenced by leaf litter depth and prey abundance (Table 4); the effects on juveniles and subadults are not significant. Efficiency decreases with increased litter depth and reduced prey density (Fig. 2), this is most apparent in adults as relatively small increases in leaf litter depth cause a large increase in the abundance of small spaces providing safe refugia for small prey. In contrast, the hatchlings and juveniles are small and able to penetrate most spaces in the litter. Similarly, small streptaxids are not affected by litter depth.

Table 4. Analysis of variance of *Euglandina rosea* adult predation efficiency

Source of variance	SS	DF	MS	F	P	
Litter (cm)	0.873	1	0.873	21.294	<0.001	***
Prey abundance	0.832	1	0.832	20.297	<0.001	***
Litter & prey	0.319	1	0.319	7.770	0.008	**
Residual	1.476	36	0.041			
Total	3.5	39	0.9			

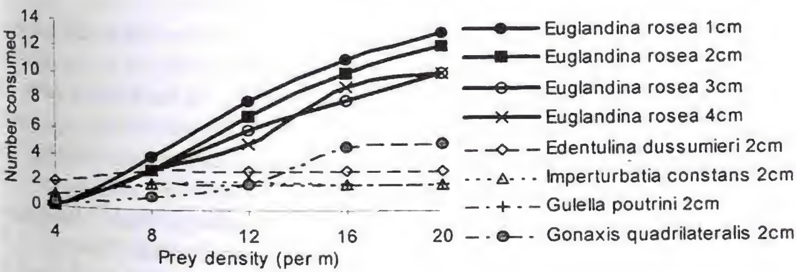

Fig. 2. Relationship between litter depth and predation efficiency

The sigmoidal curves produced fit the Holling type III functional response with a delay in predation response to increasing prey density (Real 1977) or a delay caused by a search for alternative prey. As predation is non-selective the latter explanation can be discounted. As density exceeds a critical value (in this case over 4 prey m^{-2}) predatory efficiency increases until a maximum is approached. The only significant regression is for *Euglandina rosea*, which takes the form:

$$\text{Number consumed per day} = \frac{18X^2}{10+X+1.44X^2}$$

where X = prey density. $\mathbf{R^2}$=0.89, P<0.001.

Discussion

The diet of *Euglandina rosea* in the wild includes small terrestrial molluscs which are the predominant dietary component due not to any feeding selectivity but to their abundance in leaf litter. Consumption rates are reduced for very small prey (due to detection difficulties and for large prey. Large prey appeared to be consumed less frequently due to the physical toughness of the flesh as suggested by observations where predators repeatedly struck prey without puncturing the skin. The trail following behaviour expressed during searching is dependent on prey size as larger trails represent a greater area of sensory clues which are easier to detect and follow. This selection of large prey in hunting is offset by the difficulty of consuming the prey, and the greater abundance of smaller alternatives. This situation exists where arboreal prey occur, leaving clear trails on the vegetation. When such prey are present the hunting behaviour of *E. rosea* leads it to follow the trails up the vegetation and into temporary arboreality. With the exception of avoidance of possible distasteful species *E. rosea* shows no ability to discriminate between prey species on the basis of the trail following species that are difficult to eat or inedible (such as species of Veronicellidae) as frequently as edible species of the same size class.

The predatory behaviour of *E. rosea* is such that the prey consumed most frequently will be those species that leave large trails on an open substrate and are large enough to locate easily but small enough to be consumable (effectively 5-30mm long). Such prey are uncommon in the areas studied with the exception of the Seychelles *Pachnodus*.

The above discussions of the factors affecting the success of the introductions and the selection of different prey indicate that all sympatric species are likely to be subject to predation when conditions are suitable for *E. rosea* establishment. Several extinctions of arboreal molluscs have been associated with *E. rosea* introductions, in contrast to the apparent persistence of terrestrial species. This would appear to contradict the demonstrated absence of selectivity in feeding by *E. rosea* but as demonstrated above trail following behaviour would be expected to result in heavy predation on relatively large arboreal taxa. The causes of differential extinction rates of the prey were considered with regard to the efficiency of *E. rosea* predation, the effectiveness of defences possessed by the prey and the effect of *E. rosea* on recruitment to prey populations.

In contrast to *E. rosea*, streptaxids appear to be less efficient hunters although their relatively small size enables them to locate prey in deep leaf litter. All species have lower

consumption rates than *E. rosea* and are restricted to preying on small snails. Although chemosensory lips are present in streptaxids trail following is not a significant aspect of predation which is basically a random search.

In addition to the systematic study described above the following species of Indian Ocean streptaxid were observed feeding in the wild: *Streptosele acicula* (feeding on small Subulinidae), *Gulella bicolor* (small Subulinidae), *Stereostele nevilli* (*Gonaxis souleyetianus*), *Gonospira callifera* (*Omphalatropis* spp.), *Gonospira* sp. (smaller *Gonospira* sp., *Omphalatropis* spp.) and *Gonodomus pagodus* has been recorded killing and consuming an adult *Machrochlamys indica* (O. Griffiths *pers. comm.*).

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Competitive ability and seedling establishment of *Cinnamomum verum* and *Phoenicophorium borsigianum*

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Abstract: In Seychelles the endemic palm *Phoenicophorium borsigianum* and the aggressively invasive alien *Cinnamomum verum* are competitors. The extent to which demographic variables are determinants of competitive ability in these species was investigated. The effects on competition of morphological responses to light intensity were investigated with consideration of the extent to which native plants can establish, regenerate and potentially outcompete *Cinnamomum* in important biodiversity sites. Light intensity in terms of diffuse site factors was established from computerized image analysis of heimspherical photographs. A new plant growth analysis function, leaf area/height index (ALHI), has been introduced and a principal components analysis was carried out to evaluate seedling performance. Competition between *Cinnamomum* and *Phoenicophorium* was greatly influenced by the amount of available photosynthetically active radiation. *Phoenicophorium* and probably other native palms act as a filter affecting the distribution and abundance of establishing *Cinnamomum* seedlings. Unlike *Phoenicophorium*, *Cinnamomum* could establish and regenerate only at relatively high light levels.

Keywords: demography; diffuse site factor; plant growth analysis; Seychelles

Introduction

Earlier studies on the invasion of alien plants in the Seychelles showed that *Cinnamomum verum* and *Phoenicophorium borsigianum* (hereafter *Cinnamomum* and *Phoenicophorium*) shows highest prominence values on the islands of Mahé and Silhouette (Fleischmann 1997). The endemic palm Phoenicophorium showed an outstanding potential to maintain and establish itself in secondary forests and in areas suffering from serious forest destruction, while Cinnamomum proved to be the most aggressive alien invader in Seychelles forests. This remarkably dynamic performance makes these species competitors in a series of habitats in the Seychelles. A major objective of this study was to investigate the extent to which growth in leaf area and growth in height, together with mortality and recruitment, contribute to the competitive ability of *Phoenicophorium* and *Cinnamomum*.

Phoenicophorium borsigianum Wendl. (Oncosperma alliance) is a palm endemic to the Seychelles, reaching a maximum height of 15 m. It is a hillside palm and, besides *Cinnamomum*, is probably the most prominent plant in the study area (Fleischmann 1997).

Cinnamomum verum Presl. (Lauraceae) is a cultivated and invasive shrub or tree up to 17 m tall with aromatic bark and leaves.

One approach to explain the competitive relations between the two species was to measure growth characteristics such as the relative increase in height and the relative increase in leaf area. A comparison of seedling performance of *Phoenicophorium* and *Cinnamomum* directly under different light levels was envisaged. To achieve this, a new plant growth analysis function, the so-called leaf area/height index (ALHI, see below), has been introduced and a principal component analysis (PCA) was carried out to investigate competitive ability. Furthermore, it was investigated whether or not competitive ability can

change with light intensity as a result of different morphological responses. Drawing attention to pragmatic questions related to forest management in the Seychelles, it was asked to what extent native plants like *Phoenicophorium* can establish, regenerate and potentially outcompete *Cinnamomum* in important biodiversity sites on Mahé island. In view of the increasing invasion by the alien *Cinnamomum* into relatively un-disturbed forest habitats this question becomes increasingly relevant to community conservation planning in the present day Seychelles.

Methods

Study sites

The study area comprises four sites in intermediate forests and lower parts of mountain mist forests on Mahé island, Seychelles, where the topography is relatively level. The study sites were as follows:

'La Résèrve': Plateau on ascent towards summit of Montagne Brulée, a somewhat flat area in mature *Northea - Deckenia* woods at 430 m altitude.

'*Swietenia* forest': Slightly sloping area below 'La Réserve' at 405 m altitude with rather open woods dominated by the recently introduced *Swietenia macrophylla*.

'Obelix': Ridge in Congo Rouge, West of Morne Seychellois. Moderately sloping area at 770 m altitude in mature *Northea hornei - Roscheria melanochaetes* forest.

'Jumeau': Open Plateau at 200 m altitude East of Montagne Brulée with a vegetation in post-fire succession. Last fire, December 1990.

With the exception of sites 'Jumeau' and '*Swietenia* forest', which have been somewhat disturbed by human activity in the past, these forest sites can be described as mature. 'La Résèrve' and 'Obelix' have probably seen very little human disturbance since the Seychelles were discovered 250 years ago.

Calculation of leaf area

Annual leaf area increments were calculated separately for *Phoenicophorium* and *Cinnamomum* seedlings and saplings <200 cm tall as in Fleischmann (1997a). Juveniles of this size category are hereafter called seedlings. The analysis of leaf area was performed in three different light climates: high canopy sites (diffuse site factors <mean, i.e. <29.9% DifSF [see below]); low canopy sites (DifSF=29.9–44.5%) and gaps (DifSF=98.7%. DifSF is the fraction of incident diffuse radiation transmitted by holes in the canopy; i.e. the canopy openness (Turner 1990). The light climate of the study sites and the study area are described in Fleischmann 1997a (PART-II and PART-I respectively).

Correlation between leaf area and plant height

Regression lines of average leaf area (AL) on plant height (H) were fitted by the least square method. For *Cinnamomum* a linear regression was found to fit adequately (Fig. 1a) while *Phoenicophorium* showed its best fit with an exponential regression (Fig. 1b).

Knowing that within the selected range of seedling sizes, the regression between AL

and H was basically linear in any particular light regime, it is possible to estimate the average leaf area of a seedling by its height. Increments of average leaf areas were calculated over the whole range of seedling sizes by regressing the height of a seedling at the beginning and at the end of the intercensus period (i.e. 1993 – 1994) against the corresponding average leaf area in Fig. 1. The regression functions (in terms of curves of best fit) are shown in Figures 1a and 1b.

Growth-analysis calculations

It is well known that increased production of leaf area may compensate for a lower net assimilation in low-light conditions, so that relative growth rates in height remain constant (Blackman & Wilson 1954; Hughes 1966). Moreover, plant growth rates are also affected by self-shading and by plant size. Because of this, both the increments in total leaf area per plant and the increase in height were measured simultaneously for an estimation of the above-ground growth performance of seedlings. The analysis of other growth parameters like the rate of branch production or the increase in girth were omitted for practical reasons. Furthermore, Turner (1990) showed that for seedlings and saplings <200 cm the increase in girth could not be related to different levels of PAR, and Oberbauer *et al.* (1988) reasonably inferred that height growth was more important than stem growth for saplings aspiring for canopy.

Growth analysis was used here as a tool to obtain insight into the functioning of a plant, and increments in plant height and leaf area were assumed to be key factors. Following the procedure recommended by Lambers et al. (1992) the growth performance in terms of the leaf area/height index (ALHI, see below) was factorized into two components, the relative growth rate of leaf area (RGRAL) and the relative growth rate of height (RGRH). The height (H) of a seedling is the distance between the ground and its terminal leader. The height and total leaf area of 159 *Phoenicophorium* and *Cinnamomum* seedlings were transformed to logarithms to stabilize the variances. The mathematical procedure was as follows:

$$ALHI = \frac{\ln(H_t)-\ln(H_0)}{t} + \frac{\ln(AL_t)-\ln(AL_0)}{t}$$

where ALHI is the leaf area/height index and H the height of a seedling, AL is the leaf area and ln the natural logarithm, measured at time t and at time 0. The statistics were calculated with SYSTAT (Version 5.2.1).

Leaf thickness

Leaf thickness of *Cinnamomum* and *Phoenicophorium* seedlings was measured with microcalipers. The variation in leaf thickness with light levels and seedling height was investigated.

Principal component analysis (PCA)

For the overall seedling performance of *Cinnamomum* and *Phoenicophorium* a PCA was carried out using the following parameters: (a) colonization, (b) mortality (resp. survival), (c) growth in height and (d) growth in leaf area. PCA has been widely used to define plant functional types (Golluscio & Sala 1993; Franklin *et al.* 1995). Based on the paradigm

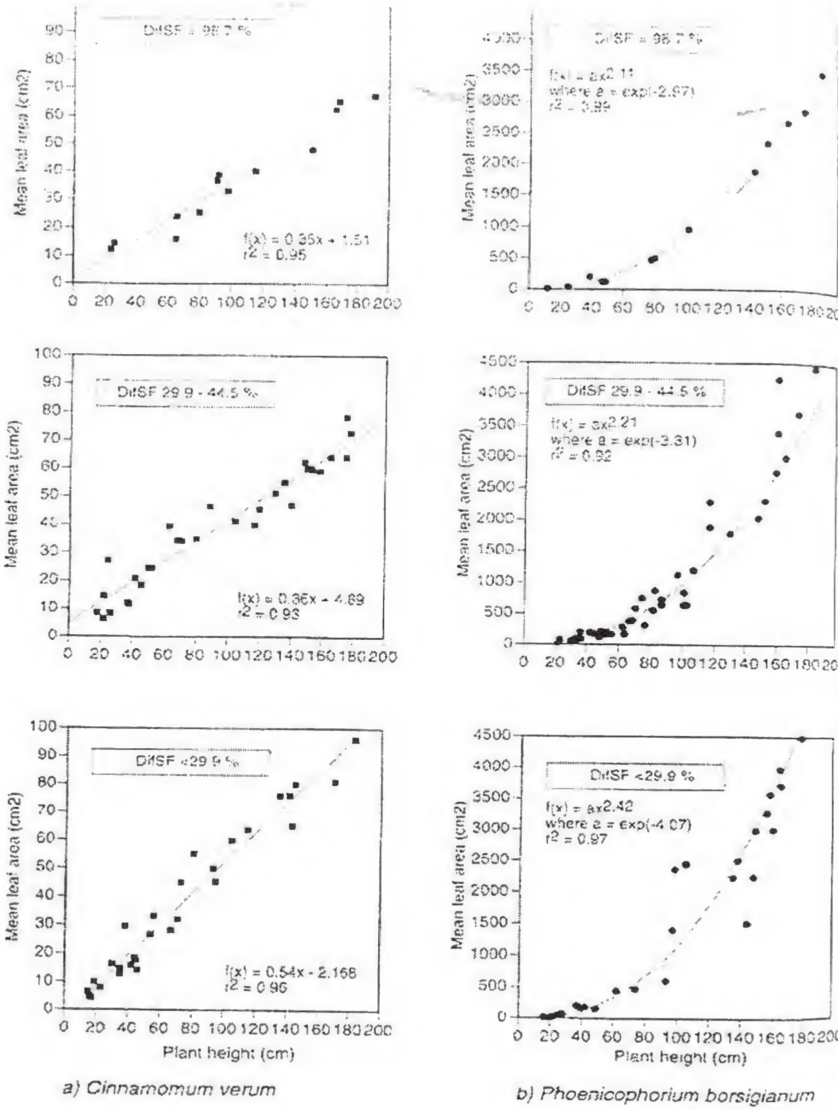

Fig. 1. Regression functions of average leaf area against plant height in three different light environments. The regression functions give an estimation of average leaf area from the height of *Cinnamomum* and *Phoenicophorium* seedlings <200 cm tall.

competitive ability of tree species in tropical forests (Whitmore 1993) a high correlation
iong the variables, with the first principal component reflecting competitive performance,
is assumed. It was evaluated whether the demographic variables - as condensed by
incipal components - predicted population change and under which light climate the
demic *Phoenicophorium* was suitable to replace *Cinnamomum*. Correlations were tested
ing Spearman's rank test and associations between continuous and nominal variables
lasses of DifSF) with the Mann-Whitney U-test.

esults

rowth and seedling establishment of *Phoenicophorium* and *Cinnamomum*

irowth

Mean leaf areas of *Cinnamomum* and *Phoenicophorium* seedlings were ignificantly larger beneath a closed canopy than in low canopy. For both species a iegative correlation between mean leaf area of seedlings and DifSF was found *Cinnamomum* rs=0.371; $p<0.005$; *Phoenicophorium* rs=0.547; $p<0.001$). This general rend was compensated in *Cinnamomum* seedlings by a significantly higher number of eaves per plant in low canopy sites ($F=19.772$; $p<0.001$). *Cinnamomum* seedlings had 3-30 eaves per plant while *Phoenicophorium* had only 1-6 leaves.

Beneath closed canopies *Phoenicophorium* showed a higher efficiency of leaf display in terms of leaf area growth rates (RGRAL) and leaf area/height indices (ALHI) (Table 1). However, under higher light levels the relative height growth rate (RGRH) of *Cinnamomum* significantly exceeded that of Phoenicophorium. Over the range of light conditions *Phoenicophorium* showed better growth performance in ALHI and significantly better performance in RGRAL than *Cinnamomum* (Fig. 2).

In areas with lower than average light levels the relationship between annual leaf area increments and seedling height differed remarkably for the two species; *Phoenicophorium* showed significantly higher increments for larger plant sizes than *Cinnamomum*. The expected positive correlation between plant height and the corresponding annual increment in leaf area was not found for *Cinnamomum* seedlings in sites with DifSF <7.5 % (Fig. 2b).

Leaf thickness

In areas of both high and low cover, the correlation between the height of *Cinnamomum* seedlings and the thickness of leaves was significant (rs=0.748; N=19; $p<0.005$). Increase in leaf thickness with increasing plant size was more pronounced in the more open sites. *Cinnamomum* leaves were generally thicker in low canopy, although not significantly (Mann-Whitney U test: U=197.5, p=0.56) sites. The thickness of *Phoenicophorium* leaves was neither correlated with the levels of light nor with the height of seedlings, except in leaves of less than 30 cm length, in which the leaf blades were slightly thinner, independent of light conditions.

Mortality

The mortality of *Cinnamomum* was strongly negatively correlated with DifSF (rs=-0.478, N=27, $p<0.01$) while *Phoenicophorium* showed no correlation (Spearman: rs=-0.170, N=19, $p>0.05$). For *Cinnamomum* the mortality was significantly higher in areas

light intensity (Mann-Whitney: U=148, p=0.003); this was not true for *Phoenicophori*
(Mann-Whitney: U=48.5, p=0.667). In high canopy sites *Phoenicophorium* did survive b
ter, though, in comparison with *Cinnamomum*, no significant difference was found betw
the two species (ANOVA: F=3.416; p=0.076).

Recruitment

In areas with below average light *Cinnamomum* recruited significantly better th *Phoenicophorium* (Mann-Whitney: U=292.0, p=0.001). Unexpectedly, recruitment of n ther species was particularly strong in low canopy sites with high levels of PAR (Table 2)

<u>Competitive ability of *Phoenicophorium* and *Cinnamomum*</u>

As predicted, significant correlations between the demographic variables and diff site factors were found. For *Cinnamomum* there were significant positive correlations wi growth (for both RGRAL and RGRH) and survival. Of all demographic variables, only t colonizing index of *Cinnamomum* was not significantly correlated with the level of lig This means that a species like *Cinnamomum* with generally high colonizing indices tends have higher competitive ability with increasing levels of PAR.

Table 1. ALHI, RGRAL and RGRH of seedlings in all plots and in plots of <mean DifSF a >mean DifSF. Asterisks represent differences between the two subgroups; *p<0.0 **p<0.005, †=p=0.05; n.s.=not significant; Cinn = *Cinnamomum*, P *Phoenicophorium*.

DifSF	ALHI (mean)			GRAL (mean)			GRH (mean)		
	Cinn.	P.	F (species)	Cinn.	P.	F (species)	Cinn.	P.	F (specie
<29.9	0.33	0.58	**3.68 †**	0.2	0.43	**5.94***	0.13	0.15	0.35 n.s.
>29.9	0.44	0.5	0.17 n.s.	0.21	0.38	2.17 n.s.	0.23	0.12	**4.84 ***
Full range	0.36	0.55	3.5 n.s.	0.2	0.41	**8.08 ****	0.16	0.14	0.39 n.s
Effect of DifSF for same species F	1.65n.s.		0.12n.s.	0.04n.s.		0.007n.s.	**10.08 ****		0.29n.s.

Table 2. Growth (ALHI), mortality (MI) and recruitment (CI) of *Cinnamomum* a *Phoenicophorium* seedlings in all plots and in plots of <mean DifSF and >me DifSF.

DifSF	*Cinnamomum*			*Phoenicophorium*		
	ALHI	MI	CI	ALHI	MI	CI
<15	0.31	30.79	28.07	0.56	16.67	9.66
15-29.9	0.35	24.4	24.47	0.60	10	5.47
30-44.9	0.56	4.76	11.16	0.50	6.67	4.54
98.7	0.35	8.33	56.95	0.50	5.56	5.09
<mean DifSF	0.33	27.99	26.37	0.58	13.64	7.76
>mean DifSF	0.44	6.06	25.25	0.50	6.25	4.71
Range of DifSF	0.36	19.06	25.91	0.55	10.53	6.47

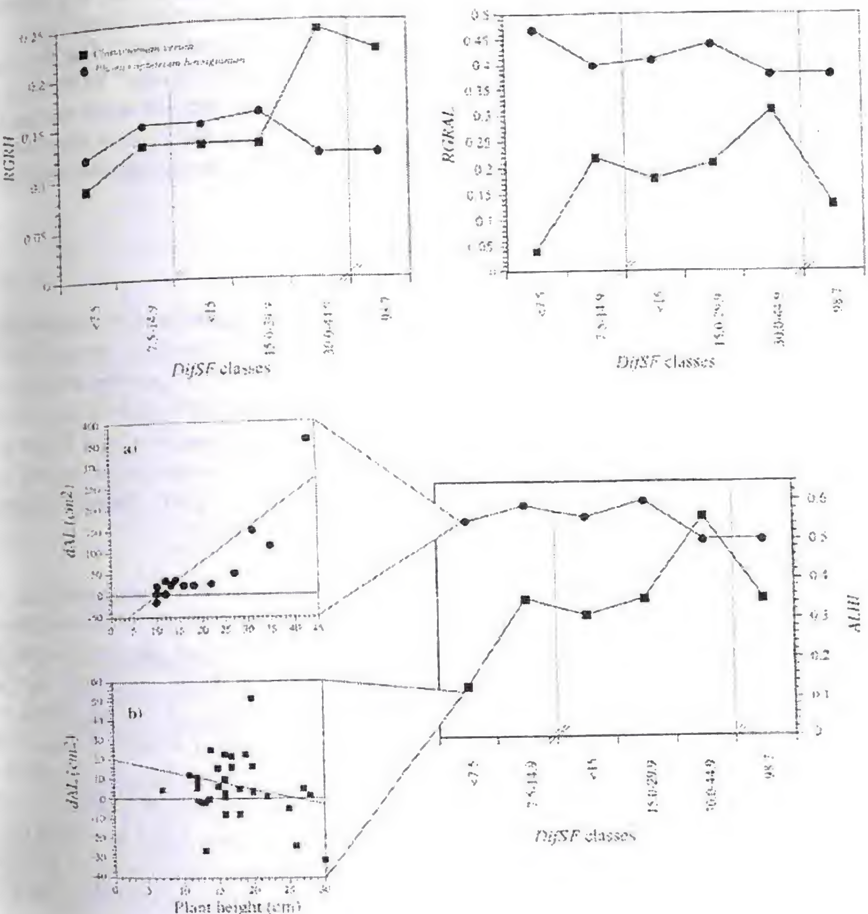

Fig. 2. Graphs of leaf area/height index (ALHI), relative growth rates of height (RGRH) and leaf area (RGRAL) against classes of DifSF for *Cinnamomum* and *Phoenicophorium* seedlings. Figs. 2a and 2b demonstrate a remarkable difference in leaf growth between the two species in very dark areas; i.e. *Phoenicophorium* showed significantly better growth performance over the range of seedling sizes. dAL, annualized increase of leaf area.

For *Phoenicophorium* the colonizing index was significantly and positiv associated with mortality over the range of available PAR. In terms of all demograph variables investigated, seedling performance of *Phoenicophorium* was significantly reduc in areas of above average light. This means that, unlike *Cinnamomum*, the enden *Phoenicophorium* tends to have higher competitive ability in shadier forest sites (Fig. 3).

The principal components analysis reflected these correlations. The first a accounted for 64.5% of all variation with the following correlations: RGRAL=0. RGRH=0.70, survival = 0.55 and recruitment = -0.54. Thus, a species' score on the f axis is a composite of the four correlated demographic variables, and reflects the predic axis of competitive ability. High scores indicate a strong tendency to outcompete rivals (F 4).

Discussion

<u>Recruitment of *Cinnamomum* vs. *Phoenicophorium*</u>

Swaine & Whitmore (1988) define pioneers by their requirement of direct sunli for germination. In Seychelles *Cinnamomum* is often found in disturbed forest areas seedlings of this species established themselves significantly better in openings than in a with a continuous forest canopy. *Cinnamomum* can therefore be distinguished as a pion On the other hand, because of its high colonizing index even in areas with light levels of – 29.9 % and its potential to establish under such light levels, *Cinnamomum* proved to relatively shade tolerant as well. However, compared with *Phoenicophori* *Cinnamomum* could not compete in the shadiest areas <7.5 % DifSF.

<u>Growth of *Cinnamomum* vs. *Phoenicophorium*</u>

ALHI gave information about the growth dynamics of *Phoenicophorium* *Cinnamomum* seedlings and their response to different levels of light. *Phoenicophor* responded significantly better in terms of RGRAL and ALHI to low gap light levels *Cinnamomum*. None of the growth parameters showed any further response to di sunlight with light levels of 98.7 % DifSF (Fig. 2). Seedlings of *Cinnamomum* v capable of responding to more open environments with much higher indices of both, RG and ALHI than to closed forest areas. This supports the hypothesis that establishment invasion of *Cinnamomum* is much facilitated by gap formation. Seeds of *Cinnamomum* germinate rapidly and logging clearings or treefall gaps are often filled by single spe stands of this plant. This observation suggests that nearby trees producing seeds at the t when a gap is formed have a competitive advantage over seedlings germinating from banks.

On the other hand, the ability of *Phoenicophorium* seedlings to increase leaf indices in low light levels without proportional increases in plant height suggests that were capable of increasing the fraction of radiation intercepted by leaves witho significant increase in the metabolic costs of producing and maintaining stems and bran to support the leaves. It seems likely that this variation in leaf display was an impo component of the surprisingly high ALHI for *Phoenicophorium* in high canopy sites DifSF <15.0 %. The comparatively modest growth response to low light combined w significantly higher mortality rate of *Cinnamomum* shows that in forest areas with D <15.0 % the endemic *Phoenicophorium* is able to outcompete *Cinnamomum*, one of most aggressive alien invaders in Seychelles.

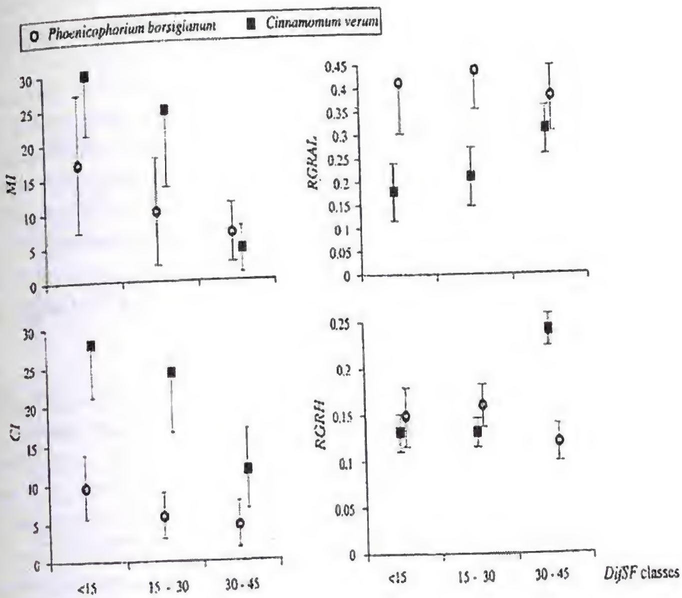

Fig. 3. The relationship between classes of DifSF and mortality (MI), colonization (CI), relative growth rate of leaf area (RGRAL) and relative growth rate of height (RGRH) for *Cinnamomum* and *Phoenicophorium* seedlings (± SE).

The slower leaf area development of *Cinnamomum* in high cover areas with available PAR of <29.9 % DifSF reduced its capacity to capture light, which then reduced its RGRH compared to *Phoenicophorium*. This study shows that competition between *Phoenicophorium* and *Cinnamomum* was probably greatly influenced by the amount of available PAR.

Phoenicophorium is able to germinate under a closed canopy, although some opening is necessary for growth to reproductive sizes. The seeds of *Phoenicophorium* are small and animal dispersed. Seedlings produce relatively large leaves in a short time and are able to persist for long periods and recover repeatedly from insect damage.

Canopy closure seems to promote seedling germination of *Phoenicophorium* through changes in the environmental conditions in the forest floor, which might be related to decreasing radiation and water evaporation. Greenhouse experiments (Espalta *et al.* 1995) have shown that reduced light levels and an associated increase in soil moisture content can have a positive effect on seedling germination and seedling growth. This is obviously true for *Phoenicophorium* for which seedling growth did not necessarily increase with a high level of PAR.

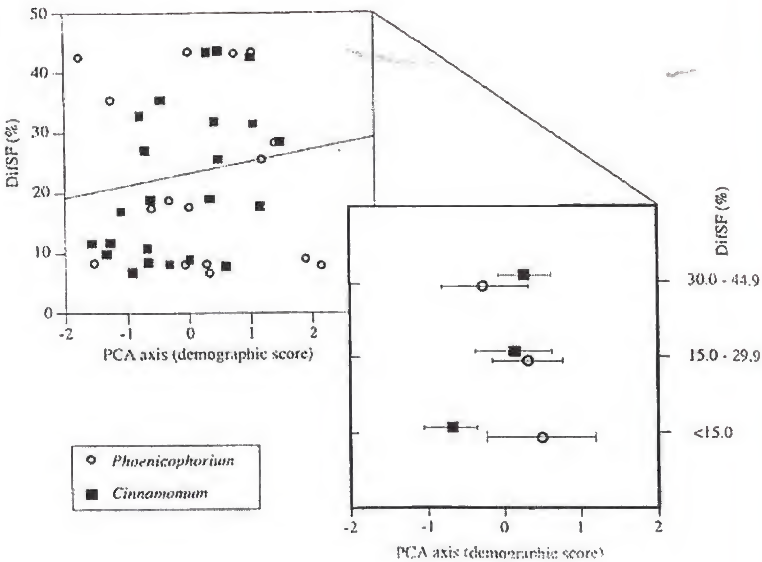

Fig. 4. The relationship between DifSF classes and the demographic score (first PCA axi
Each point represents the situation in a single sample plot. A condensed forme
values is given on the right.

Conservation

Phoenicophorium can be considered a high canopy specialist. Its shade toleran and capacity to grow even at very low light levels make this palm particularly successful competing with *Cinnamomum* and probably other invaders like *Adenanthera pavonin Tabebuia pallida, Hevea brasiliensis* etc. in shaded forest areas (i.e. DifSF<15 %). In tem of community conservation planning in Seychelles National Parks, it seems advisable to u these promising results to reduce the invasion by *Cinnamomum* in endangered biodivers sites.

For *Cinnamomum* a DifSF below 7.5 % was strongly limiting. Once the canopy w closed and radiation to the forest floor reduced to this low level, growth and further survi of *Cinnamomum* seedlings were greatly reduced. This study suggests that *Cinnamomum* well as *Phoenicophorium* seedlings may indeed demonstrate different optima along th understory cover gradient. These findings are consistent with those of Fenner (1978) a Denslow (1980) who gave evidence that some shade-tolerant tropical tree species rely optimal light intensities for seedling growth and seedling establishment within the underst

environment, and that these optima differ among species.

The fact that RGRH of both species correlated significantly with RGRAL suggests that the efficiency with which light is absorbed by a leaf depends largely on the leaf area and hence on the content of chlorophyll per unit leaf area. The question of whether the two species differ in other photosynthetic characteristics as well could not be answered in this study. Simulations for understory palms (Chazdon 1986) show that when most of the total daily PAR is diffuse radiation, which is the case in most of this study area, the relation between total daily PAR and total daily net assimilation is linear.

The data from this study suggest that *Phoenicophorium* is an important competitor with the seedlings of *Cinnamomum* and probably other invasive species and may, through its effect on the composition of the seedling pool, ultimately influence the structure and dynamics of the forest. In some of the study sites with low light levels (e.g. La Réserve) the understory is often dominated by *Phoenicophorium* treelets.

Conclusion

A comparison of *Cinnamomum* and *Phoenicophorium* showed that the former can be regarded as pioneer while *Phoenicophorium* is a high canopy species. This study demonstrated that the two species represent contrasting functional groups in the sense that *Cinnamomum* was fast-growing and light demanding and survived significantly better in open areas, whereas *Phoenicophorium* showed opposite trends. In this respect a simple paradigm - the pioneer/shade-tolerant dichotomy (Whitmore 1993) worked quite well to describe the demography of these two species. However, this simple contrast had two anomalies: First, the decreasing colonizing index with increasing levels of PAR for both species is not consistent with the pioneer/shade tolerant dichotomy. It may be that the propagation of *Cinnamomum* and *Phoenicophorium* seeds, which depends largely on birds or gravity, is enhanced in habitats near parent-trees so that gaps do not enhance recruitment if they are far from seed sources. Second, *Phoenicophorium* showed not only shade tolerance but also an outstanding plasticity in establishing itself in a broad range of light levels. This plant was even found in exposed areas on inselbergs and on denuded slopes. This study shows that a model describing forest dynamics could be based on demographic parameters.

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The ecology and conservation of Aride island, Seychelles

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Abstract: The history and ecosystems of the Aride Island Special Reserve are described. A summary of the recorded fauna and flora is given. Aride supports one of the world's largest concentrations of breeding seabirds and supports an important fauna and flora of species largely associated with the tern colony.

Key words: biodiversity, conservation, Aride

Introduction

Since its designation as a Special Reserve the island of Aride, Seychelles has been protected as an important site for the conservation of seabirds. The principal reason for its protection is the colony of breeding terns. The significance of this colony has been known since the late 1800s when the island was managed for the production of eggs for human consumption. Other taxa of significance include the Wright's gardenia *Rothmannia annae* which has been restricted to the island since 1905. Research has concentrated on the seabirds until recently. Since 1987 there has been regular monitoring of the bird populations and the flora, with increasing numbers of studies of reptiles, invertebrates and ecosystem processes. The island is managed by the Royal Society for Nature Conservation.

This paper summarises the current status of knowledge of the ecology and conservation of Aride island, drawn from published papers and the reports compiled by the island's wardens (Warman 1978; Bullock 1989; Castle & Mileto 1991; Lindstone-Scott 1993; Carty & Herzig 1995; Carty & Carty 1996; Betts 1997 & 1998; Bowler & Hunter 1999). Authorities for the taxa mentioned are given in the Aride species list (Appendix I.).

Physical geography

Aride is a small island (73.2ha). It comprises a small plateau and a rocky hill rising to 134m (Fig. 1). It has a granite base covered by leaf-and-guano derived soils. The plateau has some areas of phosphate sandstone (coral sand concreted by leached guano), loose wind-blown coral sand and quartz-grain sand from hill outwash. The low altitude and comparative isolation of the island result in sparse cloud cover and relatively low rainfall 1103-2430mm. Temperatures remain in the range experienced by nearby islands (23.9-35.5°C), an equable oceanic climate, humid, warm with few extremes.

There is a small marshy area, flooding to open water after heavy rain.

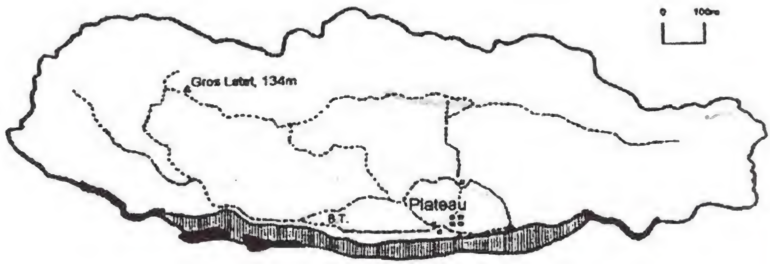

Fig. 1. Map of Aride

Marine life

The marine life of Aride has only recently been investigated. Lists of fish observe around the island have been maintained since 1987and a total of 380 species have now bee recorded. The seabed around Aride is deep (>20m), and this, combined with frequent stor damage, results in relatively restricted coral growth. Coral distribution may also have bee affected by soil erosion after forest clearance in the late 1800s and early 1900s. 5 marke coral reef transects conducted in May 1997 and again in December 1998, revealed a 92 loss of living hard coral from the southern reef in the intervening period.

Inter-tidal molluscs include a minimum of 25 species (Dahms in Bowler & Hunte 1999) and 23 species of cowrie and 174 species of cone shell have been identified fro shells deposited on the beach (Jackson in Carty & Carty 1996). 29 species of decapo crustacean have been recorded (Anderson 1994).

Flora

Of the 95 Angiosperm species recorded on Aride, 9.5% are believed to be intr duced. Of the 86 native species 1% are Seychelles endemics. There are no species natural restricted to Aride although the Seychelles population of *Peponium vogelii* is now restricte to the island and by 1905 *Rothmannia annae* only survived on Aride. The habitat of Aride classified as dry lowland *Pisonia grandis* forest (Gerlach 1998a). From the 1800s until 197 the plateau on Aride was maintained as a coconut (*Cocos nucifera*) plantation and the hi woodland coppiced to maximise nesting areas for sooty terns (*Sterna fuscata*). Since 198 management has aimed to restrict coconuts to their natural ecological niche on the strand lir and to restore the plateau woodland to a natural state. At the same time coppicing cease except for limited management to release specific native plants. This has resulted in th regeneration of natural habitats on the island. The process of regeneration continues a though there have been suggestions that a natural climax is now being approached in the hi woodland (Ayrton in Carty & Carty 1996).

The terrestrial habitats of Aride can be divided into 8 types, the areas current

occupied by each of these is summarised in Table 1. In the hill woodland regeneration has resulted in the dominance of *Pisonia grandis*, available data indicate that this is the second most abundant species but it dominates the canopy (Table 2.). *P. grandis* grows in guano rich soils and obtains additional nutrients though mycorrhizal associations (Ashford & Allwayw 1985) and through an abundance of dead seabirds. This species has sticky seeds which become entangled in bird feathers, ensuring the dispersal of the seeds. Seabirds frequently become entangled in large seed-heads and die, forming a nutrient store for the germinating seeds. The tern colonies in *P. grandis* woodland do derive some benefit from the presence of this species as its branches provide good nesting platforms and its leaves are a favoured nesting material for the lesser noddy (*Anous tenuisrostris*).

Hill woodland species such as *Rothmannia annae* may have been encouraged by the practice of coppicing as this species was retained during coppicing as its narrow growth form is ideal for providing cover without being an obstacle to egg-collection. There are suggestions that *R. annae* species may be declining due to overshadowing by *P. grandis* and *Ficus* spp., although there is no empirical evidence to support this.

Within woodland areas open glades exist. Many of the glades may have been created by clearance and soil loss during coppicing. These are mainly on areas of open rock or very shallow soil where tree growth is reduced. These glades are characterised by a low growth of herbs, grasses and sedges. Many glades are being invaded by *Asystasia* sp.

Table 1. Area of habitats on Aride

Habitat	Area covered (hectares)	Habitat	Area covered (hectares)
Beach crest	1.4	Rock	15.8
Plateau woodland	2.6	*Euphorbia* scrub	1.6
Plantation	0.9	Glade	2.0
Wetland	0.3	*Pisonia* hill woodland	44.8

Table 2. Woodland composition in 1998 (trees >2m high listed in order of abundance, other species are also present in low numbers)

Species	Plateau - trees/ha (%)	Species	Plateau - trees/ha (%)
Pisonia grandis	75.5 (41)	*Euphorbia pyrifolia*	0.4 (0)
Terminalia catappa	38.5 (21)	*Xylocarpus moluccensis*	0.4 (0)
Morinda citrifolia	33.4 (18)	Total	184.0
Cordia subcordata	7.5 (4)		
Ficus lutea	5.4 (3)	**Species**	**Hill (%)**
Thespesia populnea	4.7 (3)	*Euphorbia pyrifolia*	38
Calophyllum inophyllum	5.0 (3)	*Pisonia grandis*	35
Carica papaya	5.0 (3)	*Rothmannia annae*	15
Hernandia nymphaefolia	2.9 (2)	*Cocos nucifera*	4
Ficus reflexa	2.5 (1)	*Ficus lutea*	2
Musa sp.	1.4 (1)	*Ficus reflexa*	2
Phyllanthus casticum	0.7 (0)	*Phyllanthus casticum*	2
Barringtonia asiatica	0.4 (0)	*Morinda citrifolia*	1
Citrus sp.	0.4 (0)	*Premna serratifolia*	1

As this species has not been identified (Friedmann 1994), it is not known whether it is nativ. Historically it is probable that giant tortoises maintained the low growth of the herb layer b grazing on the fast growing *Asystasia* sp.

Monitoring of the hill vegetation since 1976 has shown that the woodland has bee encouraging into glade areas, resulting in decreases in the overall abundance of glade herb and sedges such as *Mariscus ligularis* and *Asystasia* sp., and a decrease in diversity at wood land margins. Within the woodland it has been suggested that *Ficus* spp. replace *Pisoni grandis* although recent analysis suggests that such changes are insignificant at present. Suc cessional changes suggested by available data are shown in Fig. 2.

On the plateau, a more widespread coastal forest type is believed to have existed i historical times. The regenerating woodland on the plateau has rapidly acquired some of th characteristics of marshy lowland forests throughout the granitic islands of Seychelles. It i probable that the natural habitat of the area would be mixed lowland forest. In this habita no species forms more than 80% of the trees over 2m high (Gerlach 1998a). Existing exam ples support *Terminalia catappa* at 12-40%, *Calophyllum inophyllum* at 6-30%, *Heritier littoralis* 0-17%, *Barringtonia asiatica* 0-60% and *Cocos nucifera* 10-15% (although this i artificially increased by planting). Aride's plateau supports all these species although th abundance of other species means that all except *T. catappa* are under-represented (espe-

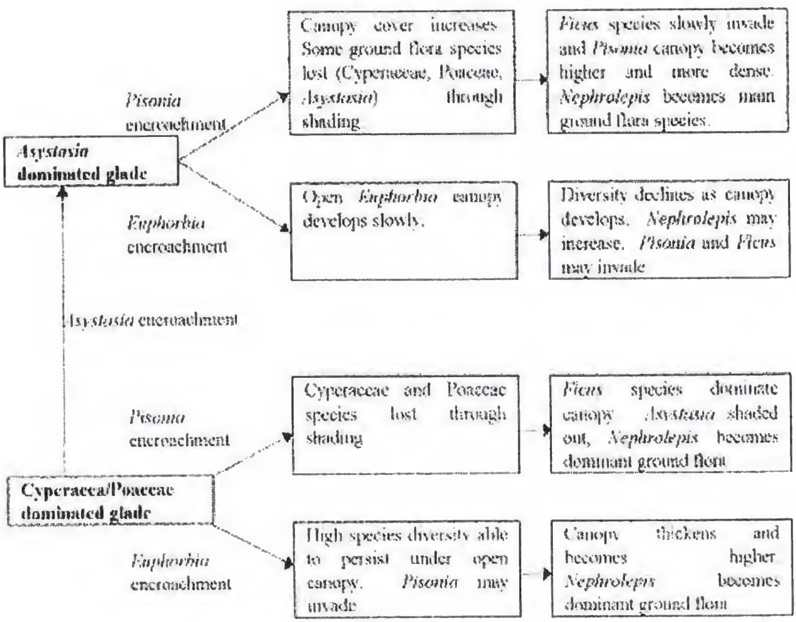

Fig. 2. Hill vegetation succession (after Ayrton in Carty & Herzig 1995)

cially *H. littoralis* and *C. inophyllum*) (Table 2). Total tree density is also relatively low. Changes recorded between 1997 and 1998 are largely due to the removal of coconut trees from the plateau. Germinating seeds of several tree species on the beach crest indicate that other plants would have been common in the Aride plateau woodland in the past as these are abundant on neighbouring islands.

Fauna

Of the Aride fauna only the vertebrates have been studied in any detail. Current species lists are relatively poor for invertebrates and observations suggest that invertebrate life is generally sparse except around the edges of the marsh. To date 239 species have been recorded, of which 223 are native. 59 Seychelles endemics have been recorded (27% of natives) (see appendix).

Of the invertebrates, flying Diptera appear to be the most abundant, especially those associated with *Morinda citrifolia*. The significance of the fauna is not known at present. The most notable records are the vulnerable millipede *Spiromanes seychellarum* which is exceptionally abundant at the edges of the marsh. The giant millipede *Sechelleptus seychellarum* is also highly abundant. Other important records include the endangered water stick-insect *Ranatra grandoculata* and the robber crab *Birgus latro* (both first recorded in 1998-9). The terrestrial mollusc fauna is very poor as would be expected in dry habitats.

The vertebrate fauna is well known. Litter inhabiting skinks are highly abundant, with the world's highest lizard densities recorded for the populations of Seychelles skink *Mabuya seychellensis* and Wright's skink *M. wrightii* (maximum estimates of 2,126±628/ha and 648±481/ha respectively). The burrowing skink *Pamelascincus gardineri* is also present. All three feed on invertebrates, fallen eggs and chicks, dead birds and on fish dropped by the breeding terns and the high level of nutrient input provided by the tern colony is the primary cause of the high lizard population densities. Geckos are similarly abundant in the form of the gecko *Ailuronyx seychellensis*. Three other species are also present but apparently less numerous, including the sucker-tailed gecko *Urocotyledon inexpectata* which is very rarely recorded. This lizard fauna supports a notable population of the lizard and bird eating Seychelles wolf snake *Lycognathophis seychellarum*.

The historical presence of terrapins on Aride has been reported but not substantiated (Bour 1984). The small marsh area would probably have been suitable for a small population of *Pelusios subniger*. In addition, tortoises were recorded in 1787 (Fauvel 1909), again the species is not known. Aldabran tortoises *Dipsochelys dussumieri* were introduced to the island in the early 1900s but were removed to Cousin and Curieuse in the 1960s and 1979 respectively. It is probable that the tortoises contributed to keeping the marsh area open by eating the emergent vegetation and excavating wallows in the dry season. Hawksbill *Eretmochelys imbricata* and green *Chelonia mydas* turtles nest on the island's beaches. The effectively protected breeding ground is important and numbers of laying turtles have increased significantly during the years of protection (Fig. 3).

The marsh area also supported the endemic freshwater fish *Pachypanchax playfairii*. This was only recorded in 1975-6 and it has been suggested to be an introduction (Beaver in Betts 1998), however it is a successful colonist of brackish pools; the eggs are probably dispersed by wading birds.

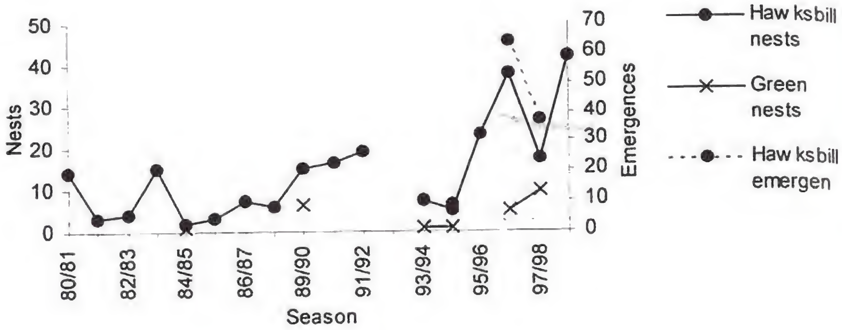

Fig. 3. Turtle numbers recorded on Aride

The most notable feature of the island is the bird life. 18 species are currently resident and there are historical records of a further 4, in addition 63 species have been recorded as migrants or vagrants. At the peak of the sea-bird breeding season there are estimated to be 746,882 pairs of birds nesting on the island (Table 3). In addition some 4,5… lesser and greater fregatebirds *Fregata ariel* and *F. minor* visit the island each year as non-breeding visitors. Of particular significance are the roseate tern *Sterna dougallii* as Aride supports the last significant breeding population in the Indian Ocean. This species appears to be particularly vulnerable to the failure of food supplies during the breeding season and complete breeding failure has occurred in several years.

Resident land birds recorded from the island include species currently absent. The black paradise flycatcher *Terpsiphone corvina* was probably lost with the historical clearance of the plateau woodland. It is doubtful whether black parrots *Coracopsis nigra* ever bred on the island as nesting trees would presumably be naturally scarce. Seychelles sunbirds (*Nectarinia dussumieri*) and Seychelles blue pigeon (*Alectroenas pulcherrima*) have recolonised the island during the last 10 years with the restoration of the plateau woodland. Magpie robins *Copsychus seychellarum* were recorded for many years although recent attempted reintroductions have failed, this may be due to food shortage and/or disease. One female bird was still present in 1999.

Fruit bats visit the island regularly but are not know to breed there. The only breeding mammals are house mice (*Mus musculus*) which are highly abundant. Research is currently being carried out into the ecology of this alien species.

Table 3. Pairs of breeding sea-birds recorded on Aride in 1998.

Species	Number	Species	Number	Species	Number
Audubon's shearwater	57,000*	Roseate tern	1,264	Lesser noddy	166,400
Wedge-tailed shearwater	195,000*	Bridled tern	89	Fairy tern	4,900
White-tailed tropicbird	624**	Sooty tern	313,400		
Red-tailed tropicbird	5	Brown noddy	8,200	**Breeding total**	746,882

* Shearwater population estimated are from 1997 data.

** Census methodology is not suited to this species - 624 is believed to be an under-estimate

Conservation

From the late 1800s until 1974 the sea-bird colonies on Aride were cropped for eggs and birds. In 1973 the island was bought by Christopher Cadbury in order to secure its future as a reserve. Since this date it has been managed by the British conservation organisation, the Royal Society for Nature Conservation. In 1979 the waters around the island were declared a Marine Reserve, affording protection for the island to 200m off-shore.

Introduced plants have been controlled as part of intensive conservation management since 1987. The majority of alien plants have been controlled or eradicated. Current problem species include *Ipomoea aquatica* spreading across the marsh area and *Alocasia macrorrhiza* in the developing plateau woodland. Although *Asystasia* sp. may be native (Gerlach 1996), it is controlled in glades in order to maintain an open nesting habitat for roseate terns. A small number of introduced animals have been identified. It is not known whether any of these represent significant conservation problems. Barn owls (*Tyto alba*) are controlled to minimise predation on the important seabird colonies and Indian mynahs (*Acridotheres tristis*) have been eradicated to prevent predation of eggs and chicks of endemic landbirds. House mice may be important invertebrate or seed predators; data are currently being collected. Measures are taken to prevent other alien species colonising the island, the risk of rat invasion is a major cause for concern. These measures have proved to be successful with the location and removal of the alien snail *Achatina fulica*. Aride is one of a small number of tropical islands to remain free of this species.

Poaching of terns and their eggs is a major problem. During the main tern breeding season night patrols are made and have had some success in discouraging poachers. The first successful prosecution of a poacher took place in 1998, however poaching continues.

Management aims to restore the island to as near a natural state as possible. This involves the management of vegetation and reintroduction of plants and animals. Two reintroductions have been carried out to date. The Seychelles warbler *Acrocephalus sechellensis* was reintroduced in 1988. This has been highly successful and Aride now supports some 75% of the world population of this species and numbers continue to rise (Fig. 4). There have been several attempts to reintroduce the Seychelles magpie robin *Copsychus sechellarum*, but so far without success, further attempts await research into food availability and disease factors. Future reintroductions may include the Seychelles black paradise flycatcher *Terpsiphone corvina*, terrapins *Pelusios* sp., giant tortoises *Dipsochelys* sp. and the freshwater fish *Pachypanchax playfairi*. Most of these are associated with the marsh restoration project currently being implemented.

Fig 4. Population growth of Seychelles warblers on Aride from 1988 to 1997.

Appendix I. Aride species list

Aride Island Research Group*
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This lists all species recorded as breeding, or suspected to breed, on Aride island. Only wild terrestrial and fresh-water species are listed. For all species the distribution outside the central (granitics plus Bird and Denis) islands of Seychelles is summarised with the following abbreviations:

End. = endemic	Ald. = Aldabra	Ami. = Amirantes	Masc. = Mascarenes
Mad. = Madagascar	Com. = Comoros	Afr. = Africa	Palaeotrop. = Palaeotropics
Pantrop. = Pantropical	Cosmo. = Cosmopolitan		

The Seychelles islands on which they have been recorded are listed in the standard order of islands used in other *Phelsuma* publications, abbreviations as follows:

M. = Mahé	SA. = St. Anne	Cerf	Moy. = Moyenne
L. = Long	Cach. = Cahée	Anon. = Anonyme	Ro. = Round (Mahé)
Sou. = Souris	Isl. = Islette	V. = Vaches Marins	Con. = Conception
Ther. = Therèse	Mam. = Mamelles	S. = Silhouette	N. = North
P. = Praslin	Cur. = Curieuse	CS. = Chauve Souris	R. = Round (Praslin)
Co. = Cousin	Coe. = Cousine	A. = Aride	Coco. = Cocos
GS. = Grande Soeur	PS. = Petite Soeur	Alb. = Albatross	Fel. = Felicité
Mar. = Marianne	LD. = La Digue	F. = Fregate	Rec. = Recifs

Only references to Aride records are cited. These are the first references to specimens or observations, the aim of this publication is to summarise specific records and not to list all citations. No citations are given for Araneae; all data for this group are from ongoing studies by M.I. Saaristo of material collected since 1974.

Species and families are listed in a standard order if a recent monographic treatment is available, otherwise all taxa are listed alphabetically.

PLANTAE

BRYOPHYTA - MUSCI

Family LEUCOBRYACEAE ***Octoblephorum albidum*** Hedw. - Afr.; M., P. & A. (Betts 1996).
Family HYPNACEAE ***Isopterygium argyroleucum*** Besch. - A. (C. Townsend pers. comm.).

PTERIDOPHYTA

Family ADIANTACEAE ***Achrosticum aureum*** Willd. - W. Indian Ocean; M., S., P., A. (Betts 1998) & Bird.
Family DAVALLIACEAE ***Nephrolepis 'biserrata'*** - M., L., S., P., A. (Castle & Mileto 1994), LD. & Bird.
Family PARKERIACEAE ***Ceratopteris cornuta*** (Pal.) Lepr. - Palaeotrop.; M., S., P. & A. (Castle & Mileto 1994
Family POLYPODIACEAE ***Phymatosorus scolopendria*** (Burm. f.) Pic.Ser. - Palaeotrop.; M., L., S., P., Co., A
(Castle & Mileto 1994 as 'Fern A.'), LD. & Bird.

Table 1. Terrestrial & freshwater species recorded on Aride

Group			Species Total	Native	% natives endemic to Seychelles	Aride
PLANTAE	Bryophyta		2	2	0	0
	Pteridophyta		4	4	0	0
	Angiospermae		95	86	1	0
ANIMALIA	Platyhelminthes		1	1	?	?
	Annelida	Oligochaeta	1	?	?	?
	Mollusca		7	5	0	0
	Chelicerata	Schizomida	1	1	100?	?
		Arachnida	38	37	42	3
		Pseudoscorpiones	1	1	0	0
		Scorpiones	1	0	0	0
		Amblypygi	1	1	0	0
		Acari	2	2	0	0
	Crustacea	Decapoda	12	12	0	0
		Isopoda	3	3	100	0
		Amphipoda	1	?	?	?
	Myriapoda	Diplopoda	5	4	50	0
		Chilopoda	5	5	0	0
		Symphyla	1	1	?	?
	Apterygota	Collembola	1	?	?	?
		Thysanura	1	?	?	?
	Insecta	Odonata	8	8	0	0
		Orthoptera	3	3	33	0
		Dictyoptera	4	1	0	0
		Isoptera	2	2	50	0
		Dermaptera	2	0	0	0
		Hemiptera	18	17	35	0
		Neuroptera	2	2	0	0
		Lepidoptera	46	44	20	0
		Diptera	31	31	45	3?
		Thysanoptera	1	1	?	?
		Hymenoptera	19	15	7	0
		Coleoptera	22	20	45	0
	Chordata	Pisces	1	1	100	0
		Reptilia	11	10	90	0
		Aves	23	20	30	0
		Mammalia	1	0	0	0

ANGIOSPERMAE (full records are given in Robertson 1989 only summary records are repeated)

Family HERNANDIACEAE ***Hernandia nymphaeifolia*** (Presl) Kubitzki - Indo-Pacific; M., S., P., A. (Castle & Mileto 1994) & LD.

Family PIPERACEAE ***Peperomia pellucida*** (L.)B.K.- Introduced; M., A. (Castle & Mileto 1994) & F.

Family MORACEAE ***Ficus benghalensis*** L. - Introduced; A. (Castle & Mileto 1994) & F. ***F. lutea*** Vahl - Afr., Mad., Comoros, Aldabra; widespread - (Castle & Mileto 1994 as *F. nautarum*). ***F. reflexa*** Thunb. - Afr.; widespread (Castle & Mileto 1994).

Family CASUARINACEAE ***Casuarina equisetifolia*** J.R. & G. Forster - SE Asia; widespread - (Castle & Mileto 1994).

Family NYCTAGINACEAE ***Pisonia grandis*** R.Br. - Indo-Pacific; M., S., Co., Coe., A. (Castle & Mileto 1994), Bird & Denis. ***Boerhavia repens*** L. - Palaeotrop.; A. (Castle & Mileto 1994), Co. & Denis.

Family AIZOACEAE ***Glinus oppositifolia*** (L.)DC.- Pantrop.; A. (Castle & Mileto 1994), Co., LD. & F.

Family AMARANTHACEAE ***Achyranthes aspera*** L. - Pantrop.; widespread (Castle & Mileto 1994). ***Alternanthera sessilis*** (L.) DC. - Introduced; M., S., P., A. (Castle & Mileto 1994) & F. ***Amaranthus***

dubius Thell. - Introduced; widespread (Castle & Mileto 1994).

Family GUTTIFERAE ***Calophyllum inophyllum*** L. - Indo-Pacific; widespread - (Castle & Mileto 1994).

Family MALVACEAE ***Abelmochus moschatums*** Medik. - Introduced; A. (Friedmann 1994, Bowler & Hun 1999). ***Hibiscus tiliaceus*** L. - Indo-Pacific; widespread (Castle & Mileto 1994). ***Sida cordifolia*** L Asia; M., A. (Castle & Mileto 1994) & Co. ***Thespesia populnea*** (L.) Soland. ex Correa - Indo-Pacific widespread (Castle & Mileto 1994).

Family LECDYTHACEAE ***Barringtonia asiatica*** (L.) Kurz - Indo-Pacific; widespread (Castle & Mileto 1994).

Family CUCURBITACEAE ***Peponium vogelii*** (Hook.f.) Engl. - Afr.; M. & A. (Castle & Mileto 1994 as *Peponium* sp., Friedmann 1994).

Family CAESALPINIACEAE ***Intsia bijuga*** (Colebr.) O.Kuntze - Indian Ocean; widespread - (Castle & Mileto 1994). ***Senna occidnetalis*** (L.) - Introduced; widespread (Castle & Mileto 1994).

Family MIMOSACEAE ***Paraserianthes falcataria*** (L.) Niels. - Introduced; widespread (Bowler & Hunter 1999).

Family PAPILIONACEAE ***Abrus precatorius*** L. - Afr.-Asia; widespread (Castle & Mileto 1994) ***Canavalia cathartica*** Thouars - Indo-Pacific; M., S., N., P., A. (Castle & Mileto 1994) & Co. ***Sesbania sericea*** (Willd.) Link - Introduced; A. (Friedmann 1994, Castle & Mileto 1994) Bird & Denis. ***Vigna marina*** (Burm.) Merr. - Pantrop.; widespread (Castle & Mileto 1994).

Family MYRTACEAE ***Eucalyptus camaldulendis*** Dehnh. - Introduced; M., A. (Castle & Mileto 1994, Friedmann 1994) & Co. ***Ludwigia erecta*** (L.) Hara - Introduced; M., N. & A. (Castle & Mileto 1994). ***Syzygium cumini*** (L.) Druce - Introduced; widespread (Castle & Mileto 1994).

Family COMBRETACEAE ***Terminalia catappa*** L. Asia; widespread (Castle & Mileto 1994).

Family EUPHORBIACEAE ***Acalypha indica*** L. - Introduced; widespread (Castle & Mileto 1994). ***Euphorbia hirta*** L. - Introduced; widespread (Castle & Mileto 1994). ***E. pyrifolia*** Lam. - Mad., Masc.; widespread - (Castle & Mileto 1994). ***E. thymifolia*** L. - Introduced; M. & A. (Castle & Mileto 1994). ***Pedilanthus tithymaloides*** (L.) Poit. - Introduced; widespread (Castle & Mileto 1994). ***Phyllanthus amarus*** Schumach. & Thonn. - Introduced; widespread (Castle & Mileto 1994). ***P. pervilleanus*** (Baillon) Müll. Arg. - Mad. widespread (Castle & Mileto 1994 as *P. casticum* and *P. nummularifolius*).

Family MELIACEAE ***Xylocarpus moluccensis*** (Lam.) Roem. - Indo-Pacific; widespread (Castle & Mileto 1994).

Family APOCYNACEAE ***Catharantus roseus*** (L.) G. Don - Introduced; widespread (Castle & Mileto 1994). ***Ochrosia oppositifolia*** (Lam.) K.Schum - Indo-Pacific; widespread (Castle & Mileto 1994).

Family ASCLEPIADACEAE ***Sarcostemma viminale*** (L.) Aiton f. - Afr.; widespread (Castle & Mileto 1994).

Family SOLANACEAE ***Datura metel*** L. - Introduced; S., P. & A. (Castle & Mileto 1994). ***Physalis peruviana*** L. - Introduced; widespread (Castle & Mileto 1994). ***Solanum americanum*** Mill. - Introduced; widespread (Castle & Mileto 1994).

Family CONVOLVULACEAE ***Ipomoea pes-caprae*** (L.) R.Br. - Pantrop.; widespread (Castle & Mileto 1994). ***I. macrantha*** Roem. & Schult. - Indo-Pacific; widespread (Castle & Mileto 1994). ***I. venosa*** (Desr.) Roem. & Schult. - Masc.?; M., Anon., S., Co., Coe. & A. (Castle & Mileto 1994). ***I. aquatica*** Forssk. - Introduced; M., S., N., Cur. & A. (Castle & Mileto 1994).

Family BORAGINACEAE ***Cordia myxa*** L. - Introduced; M. & A. (Castle & Mileto 1994). ***C. subcordata*** Lam. - Indo-Pacific; widespread (Castle & Mileto 1994). ***Heliotropium indicum*** L. - Introduced; widespread (Castle & Mileto 1994). ***Tournefortia argentea*** L.f. - Indo-Pacific; widespread (Castle & Mileto 1994).

Family VERBENACEAE ***Premna serratifolia*** L. - Indo-Pacific; widespread - (Castle & Mileto 1994).

Family LABIATAE ***Plectranthus amboinicus*** (Lour.) Spreng. - Asia; M., S., N., P., Co. & A. (Bullock 1989 as *Coleus subfrutectosus*, Castle & Mileto 1994, Friedmann 1994).

Family ACANTHACEAE ***Asystasia* sp. B.** - ?; widespread (Castle & Mileto 1994 as *A. gangetica*).

Family GOODENACEAE ***Scaevola sericea*** Vahl - Indo-Pacific; widespread (Castle & Mileto 1994).

Family RUBIACEAE ***Morinda citrifolia*** L. - Indo-Pacific; widespread (Castle & Mileto 1994). ***Pentodon pentandrus*** (Schumach. & Thonn.) Vatke - Afr.; widespread (Castle & Mileto 1994). ***Rothmannia annae*** (Wright) Keay - End.; M., S., P., A. (Castle & Mileto 1994) & Fel.

Family COMPOSITAE ***Vernonia cinerea*** (L.) Less. - Introduced; widespread (Castle & Mileto 1994).

Family AGAVACEAE ***Agave sisalana*** (Perr. ex Engelm.) Drumm. & Prain - Introduced; widespread (Castle & Mileto 1994).

Family MARANTACEAE ***Maranta arundinacea*** L.- Introduced; M., N., A.(Robertson 1987). F & Bird.

Family CANNACEAE ***Canna indica*** L. - Afr.; M., A. (Robertson 1987) & Bird.

Family BROMELIACEAE ***Ananas comosus*** (L.) Merr. - Introduced; widespread (Castle & Mileto 1994).

Family AMARYLLIDACEAE ***Hymenocallis littoralis*** (Jacq.) Salisb. - Introduced; widespread (Castle & Mileto 1994). ***Scadoxus multifolorus*** (Martyn.) Raf. - Introduced; A. (Castle & Mileto 1994).

Family PALMAE *Cocos nucifera* L. - Indo-Pacific; widespread (Castle & Mileto 1994).
Family PANDANACEAE *Pandanus balfourii* Mart. - End.; widespread (Castle & Mileto 1994).
Family ARACEAE *Alocasia macrorrhiza* (L.) G.Don - Introduced; widespread (Roberston 1987, Castle & Mileto 1994.). *Amorphophallus paeoniifolius* (Dennst.) Nicolson - Introduced; M., S., P. & A. (Castle & Mileto 1994).
Family PORTULACACEAE *Portulaca oleracea* L. - Cosmo.; widespread (Roberston 1987)
Family CYPERACEAE *Cyperus alopecuroides* Rottb. - Afr.; M., S., A. (Robertson 1987) & Co. *C. compressus* L. - Pantrop.; M., N., F & A. (Robertson 1987). *C. distans* L. - Pantrop.; M. & A. (Castle & Mileto 1994). *Fimbristylis complanata* (Retz.) Link - Pantrop.; widespread (Robertson 1987). *Kyllinga polyphylla* Willd. Ex Kunth - Afr.; widespread (Robertson 1987). *Mariscus dubius* (Rottb.) Fischer - Palaeotrop.; widespread (Robertson 1987). *M. ligularis* (L.) Urb. - Pantrop.; widespread (Robertson 1987). *M. penduncutatus* (R.Br.) Koyama - Pantrop.; M., P., A. (Robertson 1987) & F. *Pycreus polystachyos* (Rottb.) P.Beuav. - Pantrop.; widespread (Robertson 1987).
Family POACEAE *Bambusa vulgaris* Schrad. Ex Wendl. - Introduced; P., A. (Robertson 1987, Castle & Mileto 1994) & F. *Chloris barbata* (L.) Ws. - Introduced; M., L., N., A. (Carty & Carty 1996) & F. *Cyndodon dactylon* (L.) Pers. - Pantrop.; widespread (Robertson 1987). *Dactyloctenium ctenoides (Steud.) Bosser* - Pantrop.; widespread (Robertson 1987). *Digitaria horizontalis* Willd. - Pantrop.; widespread (Robertson 1987). *Elusine indica* (L.) Gaertn. - Pantrop.; widespread (Robertson 1987). *Enteropogon sechellensis* (Baker) Dur.&Schinz - Palaeotrop.; widespread (Robertson 1987). *Eragrostis tenella* (L.) P.Beauv. - Pantrop.; widespread (Castle & Mileto 1994). *Panicum brevifolium* L. - Palaeotrop.; widespread (Robertson 1987). *P. maximum* L. - Afr.; widespread (Robertson 1987). *Pennisetium polystachyon* (L.) Schult. - Palaeotrop.; widespread (Robertson 1987). *Setaria barbata* (Lam.) Kunth - Introduced; M., S., N., A. (Robertson 1987) & F. *Sporobolus virginicus* (L.) Kunth - Pantrop.; widespread (Robertson 1987). *Stenotaphrum dimidiatum* (L.) Brongn. - Palaeotrop.; widespread (Robertson 1987). *S. micranthum* (Desv.) C.E.Hubb. - Indo-Pacific; widespread (Robertson 1987).

ANIMALIA

PLATYHELINTHES ?sp. - A. (Gerlach in Betts 1998)

ANNELIDA
OLIGOCHAETEA ? sp. (Rowley & Warman 1979; Gerlach in Betts 1998)

MOLLUSCA
Family SUBULINIDAE *Allopeas gracile* (Hutton) - Pantrop.; most islands - A. (Bullock 1989). *Opeas pumilum* (Pfeiffer) - Pantrop.; most islands - A. (Bullock 1989). *Subulina octona* Bruguière - Pantrop.; most islands - A. (Rowley & Warman 1979 as "*Streptostele* sp.??;)Bullock 1989).
Family PUPILLIDAE *Gastrocopta tripunctata* Morelet - Mad; M., Anon., S., P, A. (Bullock 1989) & F.
Family ASSIMINEIDAE *Syncera nitida* (Pease, 1864) - Indo-Pacific; M., S. & A. (Gerlach in Betts 1998).
Family ELOBIIDAE *Melampus lividus* Deshayes - Indo-Pacific; M., Moy., S., P. & A. (Bullock 1989).
Family TRUNCATELLIDAE *Truncatella guerini* Villa - Indo-Pacific; M., SA., Ro., S., P. & A. (Bullock 1989).

CRUSTACEA
DECAPODA
Family COENOBITIDAE *Birgus latro* (Linnaeus) - Pantrop.; A. (Bowler & Hunter 1999). *Coenobita brevimanus* Dana, 1852 - Indo-Pacific; S. & A. (Anderson 1994). *C. perlatus* (Milne Edwards, 1837) - Indo-Pacific; S. & A. (Anderson 1994). *C. rugosus* (Milne-Edwards, 1837) - Indo-Pacific; A. (Anderson 1994).
Family GECARCINIDAE *Cardisoma carnifex* (Herbst, 1784) - Indo-Pacific; M., S., P. & A. (Anderson 1994).
Family OCYPODIDAE *Ocypode ceratopthalma* (Pallas) - Indo-Pacific; M., S., P., Co., Coe. & A. (Rowley & Warman 1979; Anderson 1994). *O. cordimana* (Desmarest, 1825) - Indo-Pacific; M., S., Co., A. (Anderson 1994) & Bird.
Family GRAPSIDAE *Geograpsus crinipes* (Dana, 1851) - Indian Ocean; S. & A. (Anderson 1994). *G. grayi* (Milne-Edwards, 1853) - Indo-Pacific; A. (Anderson 1994). *G. stormi* (De Man, 1895) - Indo-Pacific; A. (Anderson 1994). *Grapsus tenuicrustatus* (Herbst, 1783) - Indo-Pacific; M., S. & A. (Anderson 1994). *Metopograpsus messor* (Foskål, 1775) - W. Indian Ocean; M. & A. (Anderson 1994).

ISOPODA

Family ARMADILLIDAE ***Reductioniscus costulatus*** Kesselyak, 1930 - End.; M., S., P., A. (Gerlach in Betts 1998) & Cur. ***Sphaerillo maculosus*** Budde-Lund, 1904 - End.; M., S. & A. (Gerlach in Betts 1998).

Family IRMAOSIDAE ***Irmaos sechellarum*** Ferrara & Taiti, 1983 - End.; M., S. & A. (Gerlach in Betts 1998).

AMPHIPODA **? sp.** (Gerlach in Betts 1998)

ARACHNIDA

ARANEAE

Suborder **ARANEOMORPHA**

Family ARANEIDAE Simon, 1895 ***Argiope trifasciata*** (Forskål, 1775) - Afr.; P. & A. ***Cyclosa camelodes*** (Thorell, 1878) - Pantrop.; A. ***Cyrtophora citricola*** (Forskål, 1775) - Pantrop.; M., S., P., A., Cur., LD. ***Drexelia bifida*** (Tullgren, 1910) - Afr.; M., S. & A.

Family CLUBIONIDAE Wagner 1887 ***"Clubiona" nigromaculosa*** Blackwall, 1877 - End.; M., Anon., S., Co. A. (Saaristo 1995, Betts 1996 as *C. mahensis*).

Family CORINNIDAE Karsch, 1880 ***Oedignatha scrobiculata*** Thorell, 1881 - Indo-Pacific; M., S., P., Cu., Co. & A. **Genus ign 1. sp. 1**. - End. ?; A.

Family GNAPHOSIDAE Banks, 1892 (= Drassidae Sundevall, 1833) ***Camillina aldabae*** (Strand, 1907) - Ald.; A. ***C. cordifera*** (Tullgren, 1910) - Afr.; M., P., Cu., Co. & A. ***Xerophaeus* sp.** ; End.; M. & A.

Family PHOLCIDAE ***Modisimus culicinus*** (Simon, 1893) - Pantrop.; P., Cu., Co., A. & GS. ***Micropholcus fautoti*** (Simon, 1887) - Indo-Pacific/Palaeotrop.; Co. & A.

Family LINYPHIIDAE Blackwall, 1859 ***Nesioneta benoiti*** (van Helsdingen, 1978) - Palaeotrop.; M., S., P., Co. A., PS & LD.

Family LYCOSIDAE Sundevall, 1833 ***Trochosa urbana*** (O. Pickard-Cambridge, 1878) - Afr.; M., S., P. & A. ***Bristowiella seychellensis*** (Bristowe, 1973) - End.; M., P., Cu. & A.

Family OONOPIDAE Simon, 1890 ***"Gamasomorpha" tirchinalis*** (Benoit, 1979) - End; M., P. & A. (Betts 1998). ***Brignolia cubana*** Dumitresco & Georgesco, 1983 - Introduced; A. ***Gamasomorpha* sp.** - End. A. (Saaristo pers. comm.). ***Ischnothyreus peltifer*** (Simon, 1891) [= *I. sechellorum* Benoit, 1979] Pantrop.; M., P. & A. ***Opopea lena*** Suman, 1965 - Indo-Pacific/Palaeotrop.; M., P. & A.

Family OXYOPIDAE Thorell, 1870 ***Oxyopes dumontii*** (Vinson, 1863) - Mad.; M., S. P. & A.

Family SALTICIDAE Blackwall, 1841 ***Myrmarachne constrictus*** (Blackwall, 1877) - End.; L. , S., P., A. Denis. ***Harmochirus* sp.** - End; A. ***Hyllus acutus*** (Blackwall, 1877) - End.; M., Cerf, S., P., A., Denis & P. ***Heliophanus activus*** (Blackwall, 1877) - End.; M., S., P., Cur., Coe. & A.

Family SCYTODIDAE Blackwall, 1864 ***Scytodes fusca*** (Walckenaer, 1837) - Pantrop.; M., P., Cur., Co., A. (Saaristo 1997) & LD.

Family SELENOPIDAE Simon, 1897 ***Selenops secretus*** Hirst, 1911 - End.; M., S., P., Coe., A. & Frég.

Family TETRAGNATHIDAE Menge, 1866 ***Nephila inaurata*** (Walckenaer, 1841) - W. Indian Ocean; M., S., P. Cur., Co., A., LD & Frég. ***Dyschiriognatha argyrostilba*** O. Pickard-Cambridge, 1876 - Afr.; A.

Family THERIDIIDAE Sundevall, 1833 ***'Achearanea' labarda*** Roberts, 1983 - End.; A. ***Argyrodes rostratus*** Blackwall, 1877 - End.; M., S., A., Cur. & LD. ***Coleosoma blandum*** O.Pickard-Cambridge, 1882 Pantrop.; M., A. & Cu. ***C. floridana*** (Banks, 1900) - Pantrop.; M., S., P., Cu., A. & LD. ***Dipoena spundana*** Roberts, 1978 - End.; S., A., Cu., LD. ***Anelosimus placens*** (Keyserling, 1884) - End.; M., P. Cu. & A. ***"Theridion" clabnum*** Roberts, 1978 - End.; A.

Family THOMISIDAE Sundevall, 1833 ***"Thomisus" stenningi*** Pocock, 1900 [= *T. citrinellus*] - Afr.; M., S. & A.

Family ULOBORIDAE Thorell, 1869 ***Uloborus plumipes*** Lucas, 1846 - Cosmo.; M., S., P., A. & Cur -

ACARI

Family ARGASIDAE ***Ornithodoros capensis*** Indo-Pacific; A. (J. Ramos pers. comm.).

Family IXODIDAE ***Amblyomma loculosum*** Neumann,1907 - Indo-Pacific; A. (Warman 1978), Co. & Bird

AMBLYPYGI

Family TARANTULIDAE ***Phrynictus scaber*** (Krapelin, 1898) - Masc.; Co., Coe., A. (Betts 1998) & F.

PEDIPALPI

Family HUBBARDIIDAE **Sp. ?** - ?; A. (Gerlach in Betts 1998 as *Schizomus similis*).

PSEUDOSCORPIONES
Family WITHIIDAE ***Withius piger*** (Simon) - A. (M. Harvey, pers. comm.).

SCORPIONES
Family SCORPIONIDAE ***Isometrus maculataus*** (Geer, 1777) - Introduced; M., S., Co., A. (Rowley & Warman 1979 as "Scorpionida indet"; Hunter & Bowler *pers. obs.*) & F.

UNIRAMIA
SYMPHYLA
Symphyla sp. - ?; A. (Gerlach in Betts 1998).

MYRIAPODA
CHILOPODA
Family GEOPHILIDAE ***Mecistocephalus angusticeps*** (Ribaut, 1914) - Afr.; S., P., Cur. & A. (NPTS U1999.1). ***Nesogeophilus leptochilus*** (Brölemann, 1931) - Asia; M., P., Cu. & A. (NPTS U1999.2). ***Tyggarup javanicus*** Attems, 1907 - Asia; M., P. & A. (Gerlach in Betts 1998).

Family SCOLOPENDRIDAE ***Cryptops philammus*** Attems, 1900 - Afr.; M., S., P., Cur. & A. (Gerlach in Betts 1998 as *Lithobius* sp.; NPTS U1999.3). ***Scolopendra subspinipes*** Leach - Pantrop.; M., S., P., A. (Rowley & Warman 1979 as "*Scolopendrium* sp.") & F.

DIPLOPODA
Family PACHYBOLIDAE ***Spiromanes seychellarum*** Saussure & Zehntner, 1902 - End.; S. & A. (Gerlach in Betts 1998). ***Trigoniulus corallinus*** (Eydoux & Souleyet, 1841) - Pantrop.; M., S., P., A. (Gerlach in Betts 1998 as *T. goesi*) & Fel.
Family PARADOXOSOMIDAE ***Orthomorpha gracilis*** (Koch, 1847) - Pantrop.; M., S. & A. (Gerlach in Betts 1998).
Family PSEUDOSPIROBOLELLIDAE ***Pseudospirobolellus avernus*** (Butler, 1876) - Pantrop.; M., Co., A. (Gerlach in Betts 1998 as *Eucarlia alluaudi*) & Fel.
Family SPIROSTREPTIDAE ***Sechelleptus seychellarum*** (Desjardins, 1834) - End. gen.; SA., V., S., Co., Coe., A. (Gerlach in Betts 1998), Fel., LD. & F.

HEXAPODA
APTERYGOTA
COLLEMBOLA **? sp.** (Gerlach in Betts 1998).
THYSANURA **? sp.** (Rowley & Warman 1979).

INSECTA

ODONATA
Family AESCHNIDAE ***Anax guttatus*** (Burm., 1839) - Asia; M., S. & A. (Carty & Carty 1996, Bowler & Hunter 1999). ***Hemianax ephippiger*** (Burmeister, 1839) - Palaeotrop.; M., A. (Carty & Carty 1994, Bowler & Hunter 1999 - non breeding) & F.
Family AGRIONIDAE ***Ceriagrion glabrum*** (Burm., 1839) - Afr.; S., P. & A. (Bullock 1989, Carty & Carty 1996, Bowler & Hunter 1999). ***Ischnura senegalensis*** (Rambur, 1842) - Afr.; M., N., P. & A. (Betts 1998 - non breeding).
Family COENAGRIONIDAE ***Agriocnemis pygmaea*** (Selys, 1877) - Asia; M., S., P., A. (Carty & Carty 1996 - non breeding) & LD.
Family LIBELLULIDAE ***Diplacodes lefebvrei*** (Rambur, 1842) - Palaeotrop.; M., S., A. (Bowler & Hunter 1999 - non breeding) & LD. ***Diplacodes trivialis*** (Rambur, 1842) - Asia; M., S., P. & A. (Bullock 1989, Carty & Carty 1996, Bowler & Hunter 1999). ***Orthetrum stemmale*** (Selys, 1877) - Afr.; M., Cerf, S., P., Co., Coe., A. (Bullock 1989, Carty & Carty 1996, Bowler & Hunter 1999), LD., Bird & Denis. ***Pantala flavescens*** (Fabricius, 1798) - Pantrop.; S. & A. (Bowler & Hunter 1999). ***Rhyothemis semihyalina*** (Desjardins, 1832) - Afr.; M., N., P., A. (Bullock 1989, Carty & Carty 1994, Bowler & Hunter 1999 - non breeding) & LD. ***Tholymis tillarga*** (Fabricius, 1798) - Asia; M., S., P., Coe. & A. (Bowler & Hunter 1999). ***Tramea limbata*** (Desjardins, 1832); Indian Ocean; M., S., P. & A. (Bullock 1989, Carty & Carty

1996, Bowler & Hunter 1999). ***Zygomma petiolata*** Rambur, 1842 - Asia; M., S., P., Coe., A. (Carty & Carty 1994, Bowler & Hunter 1999) & LD.

ORTHOPTERA

Family GRYLLIDAE ***Zarceus fallaciosus*** Bolivar, 1895 - End.; M., L., Anon., S. & A. (Gerlach in Betts 1998).
Family PHASGONURIDAE ***Conocephalus conocephalus*** - Afr.; M., S. & A. (NPTS Hr1999.4).
Family GRYLLOTALPIDAE ***Gryllotalpa africanus*** - Afr.; M., S. & A. (Rowley & Warman 1979).

DICTYOPTERA

Family BLATELLIDAE ***Lobopterella dimidiatipes*** (Bouvier, 1890) - Asia; M., L., S. & A. (Roth 1996). ***Symploce pallens*** (Stephens) - Afr.; A. (Roth 1996).
Family BLABERIDAE ***Pycnoscelus 'surinamensis'*** - Pantrop.; M., L., S., P., Coe., A. (Roth 1996), LD., Bird, Denis.
Family BLATTIDAE ***Periplaneta americana*** Linnaeus, 1758 - Introduced; widespread, A. (Rowley & Warman 1979).

ISOPTERA

Family KALOTERMITIDAE ***Kaltoermes scotti*** Holmgren, 1910 - End.; S. & A. (NPTS Hi1999.3). Family MICROTERMITIDAE ***Microtermes subtilis*** Wasmann, 1897 - Mad.; M., S. & A. (NPTS Hi1999.1-2).

DERMAPTERA

Family LABIIDAE ***Gonolabis electra*** Burr - Introduced; M., S., P., Cur., A. (Floater 1994) & LD. ***Labia minor*** (Linnaeus) - Introduced; S., A. (NPTS Hw1999.5-9) & LD.

HEMIPTERA

Family APHIDIDAE ***Pentalonia nigronervosa*** Introduced; M., S. & A. (Rowley & Warman 1979).
Family CAPSIDAE ***Sthenarus leucophilus*** Distant, 1916 - End.; M. & A. (NPTS Hh1999.23).
Family CICADELLIDAE ***Jakerella ineffectus*** Distant, 1916 - End.; M. & A. (NPTS Hh1999.16). ***Paganda virescens*** Distant, 1916 - End.; M. & A. (Hh1999.16). ***Scaphoideus vagans*** Distant, 1916 - End.; M. & A. (NPTS Hh1999.25).
Family CIMCIDAE ***Cimex marginellus*** - A. (Rowley & Warman 1979).
Family COCCIDAE **? Sp.** (Gerlach in Betts 1998).
Family DELPHACIDAE ***Sogatella kolophon*** - A. (Rowley & Warman 1979).
Family DERBIDAE ***Protista moesta*** Westwood- Afr.; M., S. & A. (Rowley & Warman 1979).
Family FULGORIDAE ***Nisa thoracica*** Distant, 1916 - End.; S. & A. (NPTS Hh1999.13). ***Osaka relata*** Distant, 1916 - End.; A. (NPTS Hh1999.15) & Co.
Family HYDROMETRIDAE ***Halobates alluaudi*** Bergroth, 1893 - Mad.; M. & A. (Rowley & Warman 1979).
Family MARGARODIDAE ***Icerya seychellarum*** (Westwood, 1855) - Cosmo.; M., S., P. & A. (Gerlach in Betts 1998).
Family NEPIDAE ***Ranatra grandocula*** Bergroth, 1893 - Mad.; M., S. & A. (Bowler & Hunter, *pers. obs.*).
Family NOTONECTIDAE ***Anisops varius*** Fieb., 1851 - Afr.-Asia; M., S., P. & A. (Rowley & Warman 1979).
Family PENTATOMIDAE **? Sp.** - A. (NPTS Hh1999.12). ***Acrosternum heegeri*** (Fieb., 1861) - Mad.; (Rowley & Warman 1979).
Family PYRRHOCORIDAE *Jourdainana rugifer* Distant, 1916 - End. gen.; A. (NPTS Hh1999.26).
Family SALDIDAE ***Sala insignis*** Distant, 1916 - End.; M. & A. (NPTS Hh1999.32).

NEUROPTERA

Family CHRYSOPIDAE ***Mallada desjardinisi*** (Navas, 1911) - Indo-Pacific.; M., L., S., P., A. (Rowley & Warman 1979 as *Chrysopa* sp.; Gerlach in Betts 1998) & Denis.
Family MYRMELEONIDAE ***Myrmeleon obscurus*** Rambur, 1853 - Afr.; M., Sil., N., A. (Rowley & Warman 1979) & Bird.

LEPIDOPTERA

Family ARCTIIDAE ***Utetheisa. pulchelloides*** Hampson, 1901 - Indian Ocean; M., S., A. (Carty & Carty 1994 as *U. pulchella*), LD. & Bird.
Family BLASTOBASIDAE ***Blastobasis intrepida*** Meyrick, 1911 - End.; M. & A. (Gerlach in Betts 1998)

Family DANAIDAE ***Danaus chrysippus*** (Linnaeus, 1758) - Palaeotrop.; M., S., P., A. (Rowley & Warman 1979) & LD.

Family GELECHIIDAE ***Lecithocera effera*** Meyrick, 1918 - Introduced; M., S. & A. (Gerlach in Betts 1998).

Family GEOMETRIDAE ***Chloroclystis gerberae*** Herb.,1964 - End; M., S. & a. (Gerlach in Betts 1998). ***Scopula minorata*** (Boisduval, 1833) - Afr.; M., S., P., A. (Rowley & Warman 1979), F. & Bird. ***Sterrha agrammaria*** (Mabille, 1900) - Mad.; M. & A. (Gerlach in Betts 1998).

Family HELIODINIDAE ***Epicroesa*** **sp.** - End.; S. & A. (Floater 1995).

Family HESPERIIDAE ***Borbo borbonica*** (Boisduval, 1833) - Masc.; M., P. & A. (Rowley & Warman 1979). ***B. gemella*** (Boisduval, 1834) - Afr.; M., S., P. & A. (Rowley & Warman 1979). ***Coeliades forestan*** (Cramer, 1782) - Asia; M., A. (Rowley & Warman 1979) & LD.

Family LITHOCOLLETIDAE ***Caloptila megalaurata*** Legrand, 1965 - End.; M. & A. (Gerlach in Betts 1998). ***Acrocercops rhombocosma*** - A. (NPTS HI1999.42).

Family LYCAENIDAE ***Lampides boeticus*** (Linnaeus, 1767) - Cosmo.; M., S. & A. (Lindstone-Scott 1993). ***Syntarucus prithous*** (Linnaeus, 1767) - Afr.; M., SA., P. & A. (Lindstone -Scott 1993). ***Zizeeria knysna*** (Trimen, 1862) - Afr.; M., S., P., A. (Lindstone-Scott 1993), Bird & Denis. ***Zizula hylax*** (Fabricius, 1775) - Afr.; M., S. & A. (Rowley & Warman 1979).

Family LYONETIIDAE ***Decadarchis trichodora*** Meyrick, 1911 - End.; M. & A. (Gerlach in Betts 1998). ***Opogona fricata*** (Meyrick, 1911) - End.; M., S. & A. (Gerlach in Betts 1998). ***O. lornatella*** Legrand, 1965 - End.; M. & A. (Gerlach in Betts 1998). ***O. tabernatella*** Legrand, 1965 - End.; M., S. & A. (Gerlach in Betts 1998).

Family NOCTUIDAE ***Achaea catella*** Guenée, 1852 - Afr.; M., S. & A. (Rowley & Warman 1979). ***Amyna octo*** (Guenée, 1852) - Pantrop.; M. & A. (Rowley & Warman 1979). ***Anticarsia irrorata*** (Fabricius, 1781) - Palaeotrop.; M., SA., S., P., A. (Rowley & Warman 1979) & F. ***Hypena masurialis*** Guenee, 1854 - Palaeotrop.; M., S., P., A. (Rowley & Warman 1979). & F. ***Nanaguna breviuscula*** Walker, 1863 - Asia; M., S. & A. (Gerlach in Betts 1998). ***Trigonoides hyppasia*** (Cramer, 1779) - Afr.; M., SA., Cerf, S., P., A. (Bowler & Hunter *pers. obs.*), Fel. & F.

Family NYMPHALIDAE ***Hypolimnas misippus*** (Linnaeus, 1764) - Indo-Pacific; M., SA., S., N., P. & A. (Bullock 1989, Carty & Carty 1996, Betts 1998). ***Cynthia cardui*** (Linnaeus, 1758) - Non-breeding migrant - M., SA. & A. (Bullock 1989, Carty & Carty 1996, Betts 1998).

Family PLUTELLIDAE ***Plutella formicatella*** Legrand, 1965 - End.; M. & A. (Gerlach in Betts 1998).

Family PYRAUSTIDAE ***Antiercta ornatalis*** (Duponchel, 1832) - Pantrop.; M., S., P., A. (Rowley & Warman 1979), Fel. & Denis. ***Diaphana duponti*** (Joannis, 1916) - Palaeotrop.; M., L., S., A. (Rowley & Warman 1979), Mar., Fel. & Denis. ***D. indica*** (Saunders, 1851) - Palaeotrop.; M., S., P., A. (Rowley & Warman 1979), Mar., F. & Bird. ***Hymenia recurvalis*** (Fabricius, 1775) - Palaeotrop.; M., A. (Rowley & Warman 1979) & Denis. ***Marasmia poeyalis*** Boisduval, 1833 - Palaotrop.; A. (NPTS HI1999.26-7). ***Pionea ablactis*** (Walter, 1859) - Palaeotrop.; M., S. & A. (J. Bowler pers. obs. 1999). ***Psara bipunctalis*** (Fabricius, 1794) - Pantrop.; M. & A. (Rowley & Warman 1979). ***Syngamia abruptalis*** (Walker, 1859) - Palaeotrop.; M., S. & A. (Gerlach in Betts 1998).

Family SATYRIDAE ***Melanitis leda*** (Drury) - Palaeotrop.; M., S., N. & A. (Carty & Carty 1996, Bowler & Hunter 1999).

Family SPHINGIDAE ***Deilephila nerii*** (Linnaeus, 1758); Palaeotrop.; M. & A. (A. Shaw photographed 1998). ***Herse convolvuli*** (Linnaeus, 1758) - Palaeotrop.; M., S. & A. (Lindstone-Scott 1993, Betts 1998, Bowler & Hunter 1999).

Family TINEIDAE ***Haplotina insectella*** - A. (J. Gerlach *pers. obs.*). ***Hapsifera chalinoea*** (Meyrick, 1908) - Afr.; A. (Gerlach in Betts 1998). ***Progonarma pagetodes*** Meyrick, 1911 - Indian Ocean; M., S. & A. (Gerlach in Betts 1998). ***Trichophaga mormopis*** Meyrick - Introduced; A. (Gerlach 1998b).

Family TORTRICIDAE ***Platypeplus aprobola*** (Meyrick, 1886) - Indo-Pacific; M,S & A (Gerlach in Betts 1998).

DIPTERA

Family AGROMYZIDAE ***Paralimna lineata*** - A. (Rowley & Warman 1979).

Family ANTHOMYZIDAE ***Anthomyia amoena*** - A. (Rowley & Warman 1979).

Family BOMBYLIIDAE ***Geron seychellarum*** Greathead - End.; M. & A. (Rowley & warman 1979).

Family CALLIPHORIDAE ***Hemipyrellia germana*** - A. (Rowley & Warman 1979).

Family CANACEIDAE ***Noticanace mahensis*** (Lamb, 1912) - End.; M. & A. (Rowley & Warman 1979).

Family CHIRONOMIDAE ***Chironomus pulcher*** - A (Rowley&Warman 1979) ***Dicrotendipes binotatus*** (Kieffer)

- A. (Rowley & Warman 1979).

Family CHLOROPIDAE ***Cadrema pallipes*** - A. (Rowley & Warman 1979).

Family CULICIDAE ***Aedes albopictus*** (Skuse, 1895) - Indo-Pacific; widespread (Rowley & Warman 1979 as *A.* sp.).

Family DROSOPHILIDAE ***Dettopsomia formosa*** Lamb, 1914 - A. (Rowley & Warman 1979) ***Drosophila nasuta*** Lamb, 1914 - Afr.; M., S. & A. (Rowley & Warman 1979). ***D. notabilis*** Lamb, 1914 - End.; A. (Rowley & Warman 1979). ***D. sechellia*** Tsacas & Bachli, 1981 - End.; M., A. (Rowley & Warman 1979 as *D. melanogaster*; Gerlach in Betts 1998) & Co. ***Mycodrosophila fracticosa*** (Lamb, 1914) - End.; A. (Rowley & Warman 1979). ***Zaprionus vittiger*** Coquillett, 1902 - A. (Rowley & Warman 1979).

Family EPHYDRIDAE ***Allotrichoma argentipraetexta*** Lamb, 1912 - End.; A. (Rowley & Warman 1979). ***Ceropsilopa longicornis*** (Lamb, 1912) - End.; A. (Rowley & Warman 1979). ***Hydrellia varipes*** Lamb, 1912 - End.; A. (Rowley & Warman 1979). *Scatella septemfenestrata* Lamb, 1912 - End.; A. (Rowley & Warman 1979).

Family MICROPEZIDAE ***Chaetonerides alluaudiae*** (Giglio-Toss, 1895) - End.; M., S. & A. (Rowley & Warman 1979).

Family MILICHIDAE ***Madiza albipennis*** Lamb, 1914 - End.; A. (Rowley & Warman 1979). ***Milichia superba*** Lamb, 1914 - End.; A. (Rowley & Warman 1979 as *M.* sp.)

Family MUSCIDAE ***Antherigona orientalis*** - Asia; A. (Rowley & Warman 1979). ***Musca domestica*** (Linnaeus, 1758) - Cosmo.; M., S., A. (Rowley & Warman 1979) & Denis.

Family ORTALIDAE ***Chrysomyza anaea*** Fabricius, 1794 - Afr.; A. (Rowley & Warman 1979).

Family PHORIDAE ***Chonocepahlus similis*** Brues, 1905 - Asia; M., S. & A. (Rowley & Warman 1979). ***Dohrniphora cornuta*** - A. (Rowley & Warman 1979).

Family SARCOPHAGIDAE ***Parasarcophaga tibialis*** (Mcq.) - A. (Rowley & Warman 1979).

Family STRATIOMYIIDAE **?**; M., S. & A. (Rowley & Warman 1979 as "*Stratiomya* sp."; Gerlach in Betts 1998 as *Anthrax villosa* [Bombyliidae]).

Family TETHINIDAE ***Dasyrhicnoessa ferruginea*** (Lamb, 1914) - End.; A. (Rowley & Warman 1979)

Family XENASTIDAE ***Xenasteia sechellensis*** End.; A. (Rowley & Warman 1979).

THYSANOPTERA *Liothrips* cf. *micrurus* - ?; M. & A. (NPTS Ht1999.2-3).

HYMENOPTERA

Family EUMENIDAE. ***Delta alluaudi*** (Perez, 1895) - End.; M., S., P., A. (Rowley & Warman 1979) & Denis. ***Odynerus sechellensis*** Dalla Torre, 1904 - Masc.; M, S., P. & A. (Rowley & Warman 1979).

Family FORMICIDAE ***Brachymyrmex cordemoyi*** Forel, 1895 - Introduced; M., Isl., S., P., A. (Muhlenberg et al. 1977), CS., Co. & GS. ***Camponotus grandidieri*** Forel, 1886 - Afr.; M., S., P., CS., Co., A. (Muhlenberg et al. 1977), Alb., PS. & F. ***C. hova*** Forel, 1891 - Mad.; M., S., P. & A. (Gerlach in Betts 1998). ***Monomorium floricola*** (Jerdon, 1851) - Intr.; M., S., P., A. (Rowley & Warman 1979), Co., CS., Alb. GS. & PS. ***Odontomachus troglodytes*** Santschi, 1914 - Afr.; M., Isl., S., P., Co., Coe., A. (Muhlenberg et al. 1977), CS., GS., & PS. ***Paratrechina bourbonica*** (Forel, 1886) - Asia; widespread (Muhlenberg et al. 1977). ***P. longicornis*** (Latreille, 1802) - Pantropical; M., Co., Coe., A. (Muhlenberg et al. 1977), CS., GS., & F. ***Phediole punctulata*** Mayr, 1866 - Afr.; M., L., Ro., S., A. (Muhlenberg et al. 1977), Mar., GS., LD. & Bird. ***Plagiolepis madecassa*** (Forel, 1892) - Mad.; M., Anon., S., P., A. (Rowley & Warman 1979), Fel. ***P. exigua*** Forel, 1894 - Pantrop.; M., S., P., A. (Warman 1978), GS. & PS. ***Tapinoma melanocephalum*** (Fabricius, 1793) - Introduced; M., S., P., Co., Coe., A. (Rowley & Warman 1979), GS & PS. ***Technomyrmex albipes*** (Smith, 1861) - Introduced; widespread (Muhlenberg et al. 1977). ***Tetramorium lanuginosum*** Mayr, 1870 - Pantrop.; M., S., A. (Rowley & Warman 1979 as *Triglyphothrix stratidens*) & Fel. ***T. simillimum*** (Smith, 1851) - Pantrop.; M., S., A. (Rowley & Warman 1979), GS. & PS.

Family MEGACHILIDAE ***Megachile seychellensis*** Cameron, 1907 - Ald,; M., Long, S., P. & A. (Rowley & Warman 1979 as *Eutrichaeria* sp.)

Family VESPIDAE ***Polistes olivaceus*** (De Geer, 1773) - Indo-Pacific; M., Moy., S., P., A. (Rowley & Warman 1979), LD. & Bird.

Familyx XYLOCOPIDAE ***Xylocopa moluccensis*** Asia; M., S. & A. (Rowley & Warman 1979).

COLEOPTERA

Family BOSTRYCHIDAE ***Dinoderus minutus*** Fabricius - Pantrop.; A. (Rowley & Warman 1979).

Family CERAMBYCIDAE **Sp?** - S. & A. (NPTS Hc1999.60). ***Coptops humerosa*** Fairmaire - End.; M., S. , N. & A. (Rowley & Warman 1979).
Family CHRYSOMELIDAE ***Biaksha minor*** Maulik, 1929 - End.; S., A. (NPTS Hc1999.57) & Denis.
Family COCCINELLIDAE ***Chilocorus nigritus*** (Fabricius) - Introduced; M., S. & A. (Rowley & Warman 1979; NPTS Hc1999.55). ***Rhodolia chermesina*** Mulsant - Mad.; M., L., S., A. (Gerlach in Betts 1998) & Denis. ***Xamerpillus gahani*** Sicard, 1912 - End. gen.; M., S. & A. (NPTS Hc1999.62).
Family CRYPTOPHAGIDAE ***Hapalips championi*** Grouvelle, 1914 - End.; M. & A. (NPTS Hc1999.79-80).
Family CURCULIONIDAE ***Baridomorpha triplaris*** Champion, 1914 - End. gen.; M., S. & A. (NPTS Hc1999.77). ***Cratopus aurostriatus*** Fairmaire, 1892 - Mad.; M., S. & A. (Rowley & Warman 1979). ***C. griseovestitus*** Linell, 1897 - End.; M., L., Anon., S., P. & A. (NPTS Hc1999.58). ***Sitophilus oryzae*** - Introduced; A. (Rowley & Warman 1979).
Family ELATERIDAE ***Alaus scotti*** Fleutiaux, 1923 - End.; M., S. & A. (Gerlach, *pers. obs.*).
Family HYDROPHILIDAE **? sp.** (Gerlach in Betts 1998).
Family PLATYPODIDAE ***Platypus* cf. *parallelus*** - A. (NPTS Hc1999.83).
Family PSELAPHIDAE ***Sunorfia fasciculata*** Raffray, 1913 - End.; P. & A. (NPTS Hh1999.81).
Family RHIZOPHAGIDAE ***Rhizophagus* cf. *dispar*** - A. (NPTS Hc1999.68).
Family SCARABAEIDAE ***Oryctes monoceros*** (Olivier, 1789) - Mad.; M., S., P., A. (Rowley & Warman 1979), Freg. & Denis.
Family STAPHYLINIDAE ***Coproporus* sp.** - A. (NPTS Hc1999.74). ***Leptusa* sp.** - A. (NPTS Hc1999.73). ***Medon strigosus*** Bernhauer, 1921 - End.; P. & A. (Hc1999.72).
Family TENEBRIONIDAE ***Pseudhadrus*** sp. - ?; A. (NPTS Hc1999.82).

CHORDATA
PISCES
Family RIVULIDAE ***Pachyplanchax playfairii*** Günther - End.; M., S., P. & A. (Warman & Todd 1979).

REPTILIA
CHELONIA
Family TESTUDINIDAE ***Dipsochelys* sp.** - End.; formerly widespread (Bour 1984).
Family PELOMEDUSIDAE ***Pelusios* sp.** - End.; formerly widespread (Bour 1984)
Family CHELONIIDAE ***Chelonia mydas*** (Linnaeus, 1766) - Pantrop.; widespread (Frazier 1984). ***Eretmochelys imbricata*** (Linnaeus, 1766) - Pantrop.; widespread (Frazier 1984).
Family COLUBRIDAE ***Lycognathophis seychellensis*** (Schlegel, 1837) - End.; M., S., P., Coue., A. (Nussbaum 1984) & F.
Family GEKKONIDAE ***Ailuronyx seychellensis*** (Dumeril & Bibron, 1836) - End.; M., SA., Anon., Con., Ther., S., P., CS., Co., Coe., A. (Warman 1978), Mar., Fel., GS., LD. & F. ***Phelsuma astriata*** Tornier, 1901 - End.; M., SA, Cerf, Moy., L., Cach. Anon., Isl., Con., Ther., S., P., Cur., CS., R., Co., Coe., A. (Warman 1978), Fel., Coco, GS., PS., Mar., LD. & F. ***Urocotyledon inexpectata*** (Stein.) - End.; M., S.; P., Cur., Cou, A. (Warman 1978), Coco, GS., Fel., LD. & F.
Family SCINCIDAE ***Mabuya sechellensis*** (Dumeril & Bibron, 1836) - End.; M., SA., L., Cerf, Ro., Moy., Cach., Anon., Pet., Isl., Con., Ther., S., N., P., Cur., CS., R., Co., Coe., A., (Warman 1978), Fel., Coco, GS., PS., Mar., LD., F., Bird & Denis. ***M. wrightii*** Boulenger, 1887 - End.; M., V., Mam., Co., Coe., A., (Warman 1978), Mar., F., Ilot & Rec. ***Pamelaescincus gardineri*** (Boulenger, 1909) - End. gen.; M., Cerf, S., P., Cur., R., Co., A. (Warman 1978), PS., GS., LD. & F.
Family TYPHLOPIDAE ***Rhamphotyphlops brahminus*** (Daudin) - Intr.; M., S., P., A. (Bullock 1989), LD. & F.

AVES
Family PROCELLARIIDAE ***Puffinus lherminieri*** Lesson, 1893 - Pantrop.; Co., Coe., A. (Warman & Todd 1984) & Bird. ***P. pacificus*** Gmelin, 1789 - Pantrop.; Co., Coe., A. (Proctor 1974) & Bird.
Family ARDEIDAE ***Butorides striatus*** (Linnaeus, 1758) - Pantrop.; widespread (Bullock 1989 - breeding not confirmed).
Family FREGATIDAE ***Phaethon lepturus*** Lácèpede & Daudin, 1802 - Pantrop.; M., S., Cur., Co., Coe. & A. (Betts 1940). ***P. rubricauda*** Boddaert, 1783 - Pantrop.; A. (Warman 1978).
Family LARIIDAE ***Anous stolidus*** (Linnaeus, 1758) - Pantrop.; Co., Coe., A. (Ridley & Percy 1958) & Bird. ***A. tenuirostris*** Temminck, 1815 - Pantrop.; Co., Coe., A. (Betts 1940) & Bird. ***Gygis alba*** Sparrm,

1786 - Indo-Pacific; M., S., P., Co., Coe.. A. (Betts 1940), LD., F. & Bird. ***Sterna anathetus*** Scopoli, 1786 - Pantrop.; Co., Coe., A. (Bullock 1989) & Bird. ***S. dougallii*** Montagu, 1813 - Cosmo.; Seche, Mam., A. (Proctor 1974). ***S. fuscata*** Linnaeus, 1766 - Pantrop.; A. (Ridley & Percy 1966), Ilot, Rec. & Bird.

Family RALLIDAE ***Gallinula chloropus*** (Linnaeus, 1758) - Cosmo.; M., S., P., Co., Coe., A. (Warman 1978), & LD.

Family COLUMBIDAE ***Streptopelia picturata*** (Temminck) - Mad.; M., S., P., Co., Coe., A. (Warman 1978), Mar., Fel. & F. ***Geopelia striata*** (Linnaeus, 1758) - Introduced; M., S., P., Co., Coe., A. (Warman 1978), Mar., Fel., LD. & F. ***Alectroenas pulcherrima*** (Sonnerat, 1768) - End.; M., S., P., A. (Betts 1998), Fel., Mar., LD. & F.

Family OTIIDAE ***Tyto alba*** (Scopoli, 1769) - Introduced; M., S., P., Co., Coe., A. (Bullock 1989) & F.

Family NECTARIDAE ***Nectarinia dussumieri*** (Hartlaub, 1860) - End.; M., S., P., Co., Coe., A. (Oustalet 1878), Mar., Fel., LD. & F.

Family PSITTACIDAE ***Coracopsis nigra*** (Linnaeus, 1766) - Comoros; P. & A. (Bullock 1989)

Family MUSCICAPIDAE ***Terpsiphone corvina*** (Newton, 1867) - End.; P., A. (Bullock 1989), LD. & Fel.

Family SYLVIIDAE ***Acrocephalus sechellensis*** (Oustalet, 1877) - End.; Co., Coe. & A. (Bullock 1989).

Family TURDIDAE ***Copsychus sechellarum*** Newton, 1867 - End.; SE., P., Co., Coe., A. (Newton 1867) & F.

Family PLOCEIDAE ***Foudia madagascariensis*** (Linnaeus, 1758) - Mad.; M., Cerf, S., P., Co., Coe., A. (Warman 1978), Mar., Fel., LD. & F. ***Foudia sechellarum*** (Newton, 1867) - End.; Co., Coe. & A. (Bullock 1989, Castle & Mileto 1994).

Family STURNIDAE ***Acridotheres tristis*** (Linnaeus, 1766) - Introduced; widespread, M., S., P., Co., Coe., A (Warman 1978), Mar., Fel., LD. & F.

MAMMALIA
RODENTIA

Family MURIDAE ***Mus musculus*** (Linnaeus, 1758) - Introduced; M., S., P., A. (Warman 1978), F. & Bird.

Uncertain records

Family PYRAUSTIDAE '***Eyodynerus sechellensis***' - Warman 1978. '***Marucca*** **sp.**' - Warman 1978

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NOTES

The robber crab *Birgus latro* on Aride Island, Seychelles

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The robber crab *Birgus latro* (Linnaeus) is one of the largest terrestrial arthropods in the world. It has a circum-tropical distribution and is able to colonise even small, remote atolls through the dispersal of its immature pelagic stages in ocean currents. The species is edible and is regarded as a highly-prized food in some areas such as Vanuatu (S. Maturin *pers. comm.*), whilst it is also viewed as a 'robber' of coconuts, which it can remove from coconut crowns using its formidable pincers. As a result of over-harvesting and persecution, the species has become scarce in many areas, and is increasingly restricted to uninhabited and reserve islands.

Within Seychelles, robber crabs remain common on Aldabra and are still present on other coralline islands such as Cosmoledo (J. Hetimier *pers. comm.*). There has always been some doubt over the status of robber crabs in the granitic islands. The inclusion of the Seychelles in a general distribution list (Haig 1984) relies on a sole specimen in Paris (Reyne 1939), together with a report of young crabs on Mahé in 1971 (Taylor 1968). The Paris specimen is labelled 'Sechelle' without further supporting details and the Mahé record is not supported by specimens or photographs (J. Gerlach *pers. comm.*). The lack of reliable records from the granitic islands is surprising, and may possibly be connected to water temperatures over the marine plateau surrounding the islands. Records of immature robber crabs on Aride Island in the period 1997 to 1998 are therefore of great interest and are presented here:

1. 1997 (precise date not known) immature specimen observed in the Volunteers' House on the Plateau at night (M. Betts pers. comm.).
2. 28th April 1998 at 20:00hrs - 12cm long individual encountered near the top of the Lodge Path (altitude c.50m). Observers: J. Bowler, R. Fanchette, A. Labonte, S. Dahms.
3. 17th August 1998 at 21:00hrs - 15cm long individual encountered in the Volunteers' toilets on the Plateau. Observers: S. Johnson, R. Threadgold.
4. 22nd December 1998 at 22:00hrs - 12cm long individual encountered c.50m up the Lodge Path from the Lodge. Observers: G. Loe, S. Maturin, J. Bowler, A. Shaw, A. Upton, J. Hetimier, J. Pillay.
5. 11th January 1999 at 21:00hrs - 15cm long individual seen and video-taped at the La Cour Well on the Plateau. Observers: C. and A. Latimer.

In all cases, the crab observed was identified as a robber crab, on account of the following features:

1. very large, powerful front pincers of equal length
2. the second pair of legs were the longest
3. pronounced point on the forehead, above and between the eyes

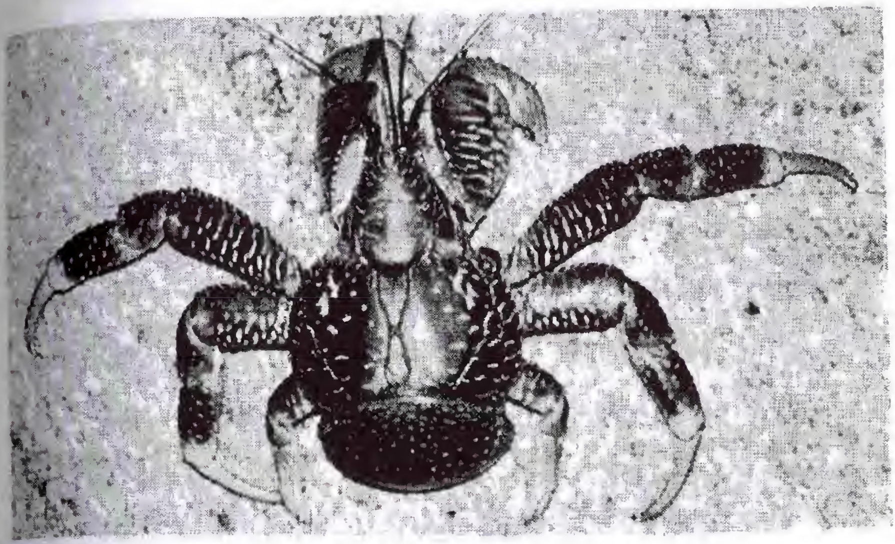

Fig. 1. Robber crab on Aride (photo: R. Shaw)

4. eye colour, blood red
5. broad body
6. broad straight abdomen tucked under body - not in an obvious spiral
7. colour - a rich purplish-brown, paler broken bands on upper sections of legs

Thus, there have been a total of 5 sightings of robber crabs on Aride since 1997. It is possible that sightings 1, 3 and 5 may refer to the same individual, and that sightings 2 and 4 may pertain to a second smaller individual, suggesting that the population of robber crabs on Aride is small. All sightings relate to immature crabs (adult males can measure 1 metre from leg-tip to leg-tip), whilst previous surveys of Aride's decapod crusteacean fauna in November 1991 (Richardson 1991) and in July to November 1993 (Anderson 1994) failed to find the species, suggesting that Aride has only recently been colonised/recolonised.

Following the third sighting, attempts were made to lure more crabs at night with opened coconuts placed at various locations on the Plateau and hill, concentrating close to the locations of previous sightings. These attempts singularly failed to attract robber crabs, attracting instead very large number (up to 100 at each site) of the large and mainly nocturnal hermit crab *Coenobita brevimanus* Dana, 1852. Robber crabs prefer to feed alone, and presumably avoided the large numbers of hermit crabs attracted to the coconuts. Sighting 4 referred to a specimen encountered en route to a baited site on the hill. Further encounters with this species will be logged and individual crabs measured in order to gain a deeper understanding of the population.

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NOTES

Keys to the Seychelles Fauna: 5. Chrysomelid leaf beetles

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The Seychelles Chrysomelidae (leaf beetles) are a relatively small but distinctive group of phytophagous beetles. There is little information on their distribution or host plants in Seychelles; *Bikasha minor* is abundant in lowland vegetation, especially *Ipomoea pes-caprae*, *Aspidomorpha apicalis* is known to feed on *Ipomoea batatas* (Maulik 1917) and *Longitarsus gardineri* was collected on *Tournefortia argentea* (Maulik 1931). *Neohispa lambacris* has been collected in *Phoenicophorium borsigianum* palm leaf bases and *Rhabdotohispa scotti* from the leaves of *P. borsigianum* and *Roscheria melanochaetes* (Maulik 1913)

1.	Flattened, rounded, head usually hidden	2. (Cassidinae)
	Not rounded, head distinct	4.
2.	Round, head obscured	3.
	Angular, front margin serrated, green, elytra tip red	*Hoplionota lila* Maulik, 1917
3.	Antennae longer than thorax	*Coptocycla leopardina* Bohemann, 1855
	Antennae projecting only slightly	*Aspidomorpha apicalis* (Klug, 1833)
4.	Elongate (L>3W), short legs	5.
	Broad (L<3W), legs often long	6.
5.	Black, L=4W, 8mm	*Nesohispa lambaciras* Maulik, 1913
	Black, pale marks, ridged, L=3W, 3-4mm	*Rhabdotohispa scotti* Maulik, 1913

Hoplionota *Coptocycla* *Aspidomorpha* *Neohispa* *Rhabdotohispa*

6. Bluish green with dark stripes	*Diactha unifasciata* (Olivier)
Not bluish green	7.
7. Hind femora stout (flea-beetles)	8.
Hind femora not stout	15.
8. Brown	9.
Black	11.
9. 2 transverse red-brown stripes on elytra	*Pratima costata* Maulik, 1929
Uniform brown	10.
Bronzy, antenna bases & legs yellowish	*Chaetocnema sundara* Maulik, 1929
10. Strongly punctured, legs stout	*Pratima variabilis* Maulik, 1919
Smooth, legs slender	*Longitarsus gardineri* Mauilk, 1929
11. Elongate (length =3xwidth)	*Chaetocnema mahensis* Maulik, 1929
Broader (length=2xwidth)	12.
12. Appendages brown	13.
Appendages black	14.
13. Hind femora usually brown, 2-2.5mm	*Chaetocnema krishna* Maulik, 1929
Hind femora black	*Biaksha minor* Maulik, 1929
14. Finely punctured elytra	*Bikasha taenuipunctata* Maulik, 1929
Strongly punctured elytra	*B. fortipunctata* Maulik, 1929
15. Hairy	*Eka nigra* Maulik, 1929
Smooth	16.
16. L<2W	17.
L>2W	18.
17. Brown with black edges	*Rhyparidula insularis* Maulik, 1929
Brown with paler elytra (Aldabra)	*Keeta aldabra* Maulik, 1929
Reddish brown (Aldabra)	*Keeta fryeri* Maulik, 1929
18. Bronzy, elytra punctured	*Rhyparida seychellensis* Maulik,1929
Shiny, elytra punctured in front half only	*Rhyparida scotti* Maulik, 1929

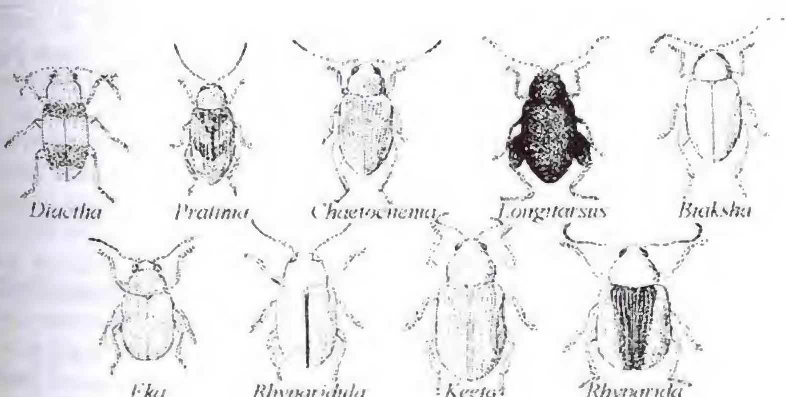

Table 1. Distribution of Seychelles Chrysomelidae

Species	Mahe	Sil.	Praslin etc.	Aldabra etc	Habitat	Range
Aspidomorpha apicalis	1909	-	-	-	mid-alt.	Africa
Biaksha fortipunctata	1909	1908	Praslin 1908	-	mid-high	
B. minor	1909	1999	Aride (1999);			
	-	-	Denis (1908)	-	lowland	
B. taenuipunctata	1909	1908	-	Aldabra 1907	mid-high	
Chaetocnema krishna	1909	1908	Praslin 1908	-	mid-high	
C. mahensis	1909	1908	-	-	high	
C. sundara	1909	-	-	-	coastal	
Coptocycla leopardina	? (1892)	-	-	-	?	Malagasy
Diactha unifasciata	1905-9	1908	-	-	all	Malagasy
Eka nigra	-	1908	-	-	coastal	
Hoplionota lila	1909	-	-	-	mid-alt.	
Keeta aldabrana	-	-	-	Aldabra 1908	low	
Keeta fryeri	-	-	-	Aldabra 1908	low	
Longitarsus gardineri	-	-	-	Providence (1905)	low	
Nesohispa lambaciras	1908-9	-	-	-	high	
Pratima costata	-	1908	-	-	high	
P. variabilis	1908-9	1909	-	-	high	
Rhabdotohispa scotti	1909	-	-	-	high	
Rhyparida scotti	1908-9	1908	-	-	high	
R. seychellensis	1908-9	1999	-	-	mid-high	
Rhyparidula insularis	-	-	-	Aldabra 1907-8	low	

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NOTES

An arachnological excursion to the granitic Seychelles, 1-26th January 1999

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In January this year I had an opportunity to collect spiders on three different islands of the granitic Seychelles, viz. Mahé, Silhouette and Cousine. Most of the time was spent on Silhouette (26 collecting days), while only three collecting days were possible on each of Mahé and Cousine. The purpose of this paper is to give a general review of the results of these collectings as well as preliminary species lists for Silhouette and Cousine (provided in the supplement). These lists include several species and even genera which were not possi-

ble to identify; they are indicated by the expression sp. ign. or genus ign.

Collecting on Mahé was done between 2-4th January 1999 and it would not have been possible without the kind help of Mr. Pat Matyot and Dr. Maureen Kirkpatrick who took me to a few suitable places on the mountains. Collecting was mainly done by sweep netting of vegetation and sieving litter and mosses. Some pitfall traps were also placed and later emptied by Mr. Matyot. In all 363 specimens were collected, making 113 different samples including 46 different species. Of them 15 are new to Mahé. Further, one new species for Mahé was found among the material collected earlier by Dr. Justin Gerlach. According to the available literature (Blackwall 1877; Simon 1893 & 1898; Hirst 1911; Bristowe 1973; Saaristo 1978, 1995a-b, 1996a-b, 1997a-b & 1998; Benoit 1978a-g & 1979; Brignoli 1978 & 1980; van Helsdingen 1978; Roberts 1978; Platnick 1979 & 1981; Grasshoff 1980; Wanless 1984 - all references are listed in the supplement) the number of spider species known from the granitic Seychelles is 167 and of these 119 have been found on Mahé. Adding the new findings will raise the number of species found on Mahé to 134.

Between 5-22nd January I had a great pleasure to visit Silhouette. During this time Dr. Gerlach and I made a great effort to collect spiders from numerous various habitats using several different collecting methods including pitfall trapping and funnelling soil and litter. This activity yielded conspicuous spider material consisting of 2012 specimens in 614 different samples. Unfortunately, because of heavy rain, higher sites could only be reached twice. Thus the main part of our material is from the lower parts of the island.

According to the above mentioned literature 51 different spider species have been recorded from Silhouette. Our material consists of 118 species of which 70 are new to Silhouette. They also include several species which are new to the granitic Seychelles or even new to science. In addition, two families, viz. Miturgidae and Mimetidae, which are new for the granitic Seychelles were recorded. Furthermore, the material collected by Dr. Gerlach between 1983-88 includes 3 species new for Silhouette. Thus the total number of spider species from Silhouette is now 124. The high species number from Silhouette compared to Mahé (10 times larger in area) is explained by the more extensive collecting on the former island, as described above. It is also worth mentioning that a well established population of a mygalomorphid spider was found on the trunks of old *Sysygium cumini* (L.) Skeels trees on Silhouette. At present even its familiar placing is uncertain as it has a mixture of characters of the Ctenizidae and Miturgidae. This is apparently the same species as was recorded by Hirst (1911) from Silhouette under the name *Conothele* sp.

My last days on Seychelles were spent on the small island of Cousine, at the kind invitation of Mr. Peter Hitchins and Ms. Stella Le Maitre. Collecting was done between 23-25th January yielding 373 specimens split into 103 samples, including 37 different species. No spiders have ever been recorded from Cousine but the material sent to me earlier by Mr. Hitchins and Ms. Le Maitre comprised 16 species while in the new material there are 29 additional species, bringing the total number on Cousine to 45. Among them is a very interesting eyeless oonopid and also a species representing a new family (Prodidomidae), for the granitic Seychelles. Unfortunately only a female of each species was collected.

As mentioned before 166 spider species have been reported from the granitic Seychelles. The new material in this report includes 28 new species for the area bringing the total to 194 species. Also three new families for the granitic Seychelles were dis-

ered and several species appear to be new to science. The notable dominance of family Oonopidae on the granitic Seychelles is an interesting phenomenon; about 20% of the known species belong to that family.

Finally it must be said that without the help of the above mentioned people it would not have been possible to arrange this collecting of spiders in Seychelles. My sincerest thanks are due to all of them. I wish also thank Mr. Ron Gerlach and Mrs. Gill Gerlach for all their valuable help during my visit on Silhouette.

NOTES

New animals in Seychelles

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Recent collections of insects from Silhouette include many new records, including several new records for Seychelles. Three of these are reported on below.

Achaea violaceofascia (Saalmüller, 1891) (Lepidoptera; Noctuidae)

This distinctive large noctuid moth was found at a light at La Passe, Silhouette on 14th January 1999 by M.I. Saaristo (NPTS HI1999.16). This species can be distinguished from all other Seychelles noctuids by its large size (60mm wing-span) and generally dark brown fore-wings. In common with other *Achaea* species the hind-wings are blackish with white patches. This species is recorded from Madagascar and Reunion. The Silhouette specimen resembles the Reunion subspecies *A. v. richardi* Viette, 1975 in size (*A. v. violaceofascia* <60mm, *A. v. richardi* = 60-65mm) and in having generally indistinct markings on the fore-wing and a reduced white bar on the hind-wings. This species is presumed to be a natural colonist. On Reunion it has been recorded feeding on Euphorbiaceae and Sapotaceae.

Hypocala deflorata Fabricius, 1775 (Lepidoptera; Noctuidae)

This highly distinctive noctuid moth was found at a light at La Passe, Silhouette on 1st August 1998 by the author (NPTS HI1998.103). It is a widespread species ranging from southern Africa to India, distinctive in the Seychelles fauna in having grey-brown fore-wings with indistinct bands in striking contrast to the bright orange hind-wings. There is a broad

black border to the hind-wings, curving into the centre. Two marginal spots are present. The wing span of the species is 30-45mm. The Silhouette specimen measures 40mm and appears to be the typical variety, with indistinctly marked greyish fore-wings. The species is probably a natural colonist.

Heteropsylla cubana (Hemiptera; Psillidae)

The *Leucaena* psillid was located at three sites around the coast in January: Pointe Zeng-Zeng (10th January) (NPTS Hh1999.12), Baie Cipailles (14th January) and La Passe (26th January). The largest population was at Pointe Zeng-Zeng which appears to be the site of the original colonisation. It feeds on *Leucaena leucocephala* and *Dendrolabium umbellatum*, causing damage to the growing shoots of the alien *L. leucocephala* but apparently no damage to the native *D. umbellatum*. The spread of this introduced species and its effects on *L. leucocephala* will be monitored. Initial observations and reports from other parts of the world suggest that this may reduce the threat posed by *L. leucocephala* invasion. *H. cubana* is a widespread species, apparently accidentally dispersed by human agency, its presence in Seychelles appears to have been first recorded by Carlström (1996) as 'leucaena psillid'.

Puliciphora borquinensis Wheeler (Diptera; Phoridae)

Three wingless female flies were found in leaf litter in the coco-de-mer (*Lodoicea maldivica*) grove at Jardin Marron. Two of these were identified by H. Disney as *Puliciphora borquinensis*, a tramp species with a worldwide distribution. The third specimen was identified as a species of *Chonocephalus*. This appears to be an undescribed species but winged males are needed to confirm identification. The larvae of *P. borquinensis* are polyphagous saprophages and it is probable that all three specimens were associated with the abundant palm fruits of the area.

Acknowledgements

I am grateful to H. Disney for his identification of the phorid flies.

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NOTES

The colour of Seychelles wolf snakes *Lycognathophis seychellensis* on Aride

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The Seychelles wolf snake *Lycognathophis seychellensis* (Schlegel, 1837) occurs in two distinct colour phases, namely black and yellow, with a third intermediate colour-phase that has variously been described as olive-brown or grey. Previous workers on Aride noted a predominance of yellow snakes amongst the larger specimens. Ian Bullock reported that 'the yellow/khaki individuals appear to be the largest, whereas the black tend to be smaller' (Bullock 1989). Castle & Mileto (1991) reported common sightings of 'both colour phases' but did not find the size difference noted by Bullock. However, Bullock's impression of a smaller number of large black snakes was confirmed by the impressions of former plantation workers on Aride who stated that most of the large snakes they observed in the 1970s on Aride were yellow in colour (R. Fanchette *pers. comm.*).

Betts (1998) collated all sightings of snakes observed in 1996-1997 according to location, size and colour, and from these and our own records in 1998, it became apparent that most large snakes on Aride were no longer yellow, and instead were predominantly darker individuals.

This short report compares recent data on the colour of snakes on Aride collected in 1996-98 with similar data collected in 1989-91 to investigate whether the ratio of snakes of different colours has changed in the intervening period.

Method

Data collected on the colour and length of snakes on Aride was collated from the Aride archives. Only records in which date and colour were recorded could be included in the analyses, and for analyses involving snakes of different sizes, the data-set was further reduced to records which also included an estimate of the length of the snake. Pertinent data were found to have been collected in two periods: 1). 1989-91 and 2). 1996-97. Additional new data were collected in 1998 (up to and including November 1998) and these were added to the more recent data-set.

Considerable variation was encountered in the description of colour of the snakes. All records referring to 'yellow', 'light', 'olive', 'olive-green' and 'khaki' individuals were assigned to the class 'yellow', whilst all other colours ranging from 'black', 'dark', 'dark brown', 'dark grey', 'grey' were assigned to the class 'dark'. Thus, for the analyses, black and intermediate colour-phases were lumped together.

There are a number of assumptions implicit in this study:

1. Snakes of the different colour phases have an equal likelihood of detection. This may not be the case since the camouflage of snakes of different colour will depend on the background substrate.

2. Individual snakes of the same colour phase were recorded an equal number of times. Again this is unlikely to be the case, since search effort was not constant and snakes living close to houses or adjacent to paths would be recorded more frequently than those inhabiting more remote sites. An attempt was made to identify individual snakes from repeat sightings of individuals of similar size and colour description within close proximity. This proved to be rather subjective, since records rarely matched exactly, whilst the distance that individual snakes are capable of moving was not known.

Results

Snakes were observed most frequently on the Plateau, although also on the hill (see also Betts 1998), and any apparent difference in frequency of sightings between these two areas could reflect observer efforts as much as any genuine difference in density between the two areas.

a). All snakes
A comparison of the ratio of yellow to dark snakes of all sizes recorded in 1989-91 with the ratio recorded in 1998-98 (Table 1) revealed that the proportion of yellow snakes was significantly lower in the latter time period (χ^2=5.06, P<0.05, d.f.=1).

b). Small snakes (<1m in length)
A comparison of the ratio of yellow to dark snakes of <1m long recorded in 1989-91 with the ratio recorded in 1996-98 (see Table 1) revealed that there was no significant difference between the two time periods (χ^2=0.37, P>0.1, d.f.=1).

c). Large snakes (>1m in length)
A comparison of the ratio of yellow to dark snakes of >1m long recorded in 1989-91 with the ratio recorded in 1996-98 (Table 1) revealed that the proportion of yellow snakes was significantly lower in the latter time period (χ^2=4.48, P<0.05, d.f.=1).

Discussion

An analysis of the colour of wolf snakes observed in 1996-1998 compared to similar data collected in the period 1989-1991, indicated that the proportion of dark-coloured snakes increased (and the proportion of yellow snakes decreased) during this period. This trend was

Table 1. Frequency of records of snake colour-phases.

	All sizes			**Small snakes**			**Large snakes**		
	Yellow	**Dark**	**Total**	**Yellow**	**Dark**	**Total**	**Yellow**	**Dark**	**Total**
1989-91	12	21	33	3	10	13	8	7	15
1996-98	28	123	151	11	54	65	15	52	67
Total	40	146	184	14	64	78	23	59	82

significant for snakes more than 1m long, but not for snakes less than 1m long, suggesting that the mortality rates to maturity of snakes of the different colour morphs has changed since 1989. A likely explanation for changes in mortality rate are the changes in habitat that have occurred on Aride in the last decade as a result of on-going management of the vegetation. These have resulted in an increase in canopy density and an increase in leaf litter, making the woodland floor environment (where the snakes live) generally more shaded and darker.

The inference from these data is that in 1989-91, yellow snakes had lower mortality rates (and dark snakes higher mortality rates), probably as a result of being better camouflaged on the open, sunlit floor of the coconut plantation, young plateau woodland, hill glades and relatively recently coppiced hill woodland, and therefore being less prone to predation. By 1996, most of the plateau had developed closed canopy coastal woodland, the glades had shrunk in size and the hill had developed a more closed canopy, resulting in more heavily shaded and litter-covered woodland floors. Such conditions would favour the camouflage of dark-coloured snakes but would increase the likelihood of detection and predation of yellow snakes.

On Aride the chief predator of wolf snakes is probably the moorhen *Gallinula chloropus* (Linnaeus, 1758), numbers of which were also higher in the latter study period (200 birds estimated in 1998), than in the early study period (86 birds estimated in May 1990, Castle & Mileto 1991). Both *Mabuya* species are likely to be predators of both snake eggs and juvenile snakes, as are various land crabs and larger specimens of the bronze gecko *Ailuronyx seychellensis* (Duméril & Bibron, 1834) (Latimer in Betts 1998).

The assumption that snakes of different colour have an equal chance of being recorded is probably not true, since the factors affecting camouflage from predators are likely to similarly affect detection by human observers. However, this would have a conservative effect on the results, since presumably yellow snakes were more easily seen on the more heavily shaded and darker leaf-littered woodland floors of the latter study period, and conversely dark snakes would have been more easily seen on the sunlit and paler woodland floors of the earlier period.

Conclusion

The available evidence concerning the colour of snakes on Aride, concurs with the subjective impression that the proportion of yellow snakes has declined in the last decade, and that the population of large snakes (over 1m) is now predominantly dark in colouration.

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Skinks as vectors of ticks parasitising roseate tern chicks

L. Davis & S. Venis

During the roseate tern *Sterna dougalii* Montagu, 1813 breeding season on Aride island (April-September), the chicks are parasitised by the adult stage of the tick *Amblyomma loculosum* Neumann, 1907. These have a significant effect on chick mortality (Ramos 1999). The larval stage of the ticks parasitising the skinks was estimated to have hatched on 15th September 1998, metamorphosing into the nymph stage approximately 30-40 days later (J. Ramos, *pers. comm.*).

This note reports on an investigation of the relationship between the locally abundant *Mabuya* skinks, ticks and the roseate chicks carried out during September-November 1998. The aim of the study was to test whether skinks play a role in the transfer of ticks and whether the species, size of skink or area affects the likelihood of skinks carrying ticks.

Methods

A quantitative study was carried out on Wright's skink *Mabuya wrightii* (Boulenger, 1889) and Seychelles skinks *M. sechellensis* (Duméril & Bibron, 1834) on Aride. An area was selected in the main roseate tern colony on the west side of the island on the woodland hill. A control area was randomly selected outside the roseate colony (and away from the sooty tern *Sterna fuscata* Linnaeus, 1766 colonies) on the woodland hill path to act as a control.

The area within the roseate colony was monitored on 3 consecutive days over a 2 week period. On each day 1 hour was spent capturing skinks with a net. The skinks were measured (snout-vent length, in cm), identified and the number and location of ticks recorded. After these details had been recorded, the skinks were marked with a small dab of paint on their rear ends in order to prevent duplication of records. The skinks were then released.

Table 1. Tick distribution

	Colony	Control	Total
with ticks	49	12	61
without ticks	11	38	49
Total	60	50	110

Table 2. Prevalence of ticks on different skink species in the roseate colony

	Wright's		Seychelles		Total
	<6cm	>6cm	<6cm	>6cm	
with ticks	1	3	2	43	49
without ticks	8	0	1	2	11
Total	9	3	3	45	60

A second monitoring period was conducted on 10th November 1998 (56 days after the estimated day of tick hatching) within the same roseate colony area. This was of only 2 hours. This second monitoring period was carried out when the roseate colony was empty of adults and the ticks would be expected to be in their nymphal stage.

Results

Control area

50 skinks were captured; 38 were Seychelles skinks and 12 were Wright's skinks. Of these, 11 (22%) had ticks attached (3 Wright's skinks and 8 Seychelles skinks). All infested skinks were at least 6cm long.

Roseate colony area

60 skinks were captured; 48 were Seychelles skink and 12 were Wright's skinks. Of the 12 Wright's skinks, 3 were longer than 6cm and each had 1 tick per skink (mean=1, s.d.=0.44). The remaining 9 small skinks had an average of 0.22 ticks per skink (s.d.=0.44). Of the 48 Seychelles skinks, 45 were longer than 6cm, these had a highly variable number of ticks (0-28, mean=6.24, s.d.=6.24). The 3 small Seychelles skinks had 0-16 ticks (mean=7.3, s.d.=8.1). Although the large skinks had a lower average number of ticks, 6 individuals had more than 16 ticks. The results are summarised in Table 1.

Position of ticks

Small Seychelles skinks had an average of 3.14 ticks between their toes, compared to 2.82 for large skinks. Ticks were found in Seychelles skink armpits in small skinks only (0.91 per skink). Wright's skinks only had ticks between their toes (small skinks only; 0.6 per skink).

Skinks in the roseate colony were significantly more likely to be infested with ticks than those from the control area (χ^2=36.81, P<0.01). Infestation was also more prevalent on Seychelles skinks than Wright's skinks (χ^2=23.4, P<0.01). Size did not have a significant effect on the probability of infestation (Seychelles skink χ^2=1.73, P>0.1; Wright's skink χ^2=1.34, P>0.1). All data are in Table 2. The levels of infestation in the roseate colony are correspondingly higher in Seychelles skinks than in Wright's skinks (Table 3). In the control area infestation was low.

In Seychelles skinks, ticks were most abundant between the toes, with small numbers of ticks in the armpits of larger skinks only. Only one tick was found on a small Wright's skink and that was in the armpit. Large Wright's skinks had slightly more ticks between the toes than in the armpits (Table 4).

From the second sampling period a total of 37 skinks were captured, of which 7 were Wright's skinks and 30 Seychelles skinks. No signs of tick infestation were found in either species at this time.

Conclusions

Within the limits of the small sample sizes it appears that skinks from the roseate tern colony were much more likely to have ticks attached than those outside the colony. Seychelles skinks (regardless of size) were significantly more likely to have ticks attached and in

greater numbers compared to the Wright's skinks. This is probably not due simply to the differences in size between the skink species as size itself was not a significant influence on the probability of tick infestation for either species, although sample sizes in some size classes were small. Size did however appear to determine the location of ticks in Seychelles skinks. Large Seychelles skinks tended to have more ticks attached, of which most accumulated between their toes. However, large skinks were more likely than small skinks to have ticks attached in their armpits.

The absence of ticks in the second sampling period should have coincided with the ticks being present in their nymphal stage. This suggests that by the time the ticks are in the nymph stage a new host has been chosen.

From this study it is possible to make the assumption that Seychelles skinks had greater numbers of ticks attached. This may be due to the fact, that whilst capturing skinks, it was noted that Seychelles skinks were more active and had larger home ranges than Wright's skinks which tended to be more sedentary and with small territories (Venis 1998). Due to Seychelles skinks being more active, the ticks have a greater opportunity to attach themselves and thus be carried around and distributed more widely over the island. It is also possible to assume that the larger skinks have larger scales, allowing the ticks to attach more readily.

From these results it would be useful to investigate the effects of skink size further (increasing sample sizes to more reliable levels and investigating the effect of scale size on tick attachment). During the study it was noted that wedge-tailed shearwaters *Puffinus pacificus* Gmelin, 1889, juvenile sooty terns and lesser noddies *Anous tenuirostris* Temminck, 1815 were infested with nymphs around their beak, eyes and legs in mid-November 1998. All birds observed with these infestations were found either on the beach (west end) or beach path. It would be interesting to monitor the ticks, to test whether or not growth patterns coincide with other sea-bird nesting periods, which species act as the main hosts in the nymphal stage and whether roseates are more susceptible to attack by adult ticks than are other tern species.

Table 3. Numbers of tick per skink

Species		Colony			Control		
		n	mean	s.d.	n	mean	s.d.
Seychelles	<6cm	3	7.3	8.1	6	0	0
	>6cm	45	6.24	7.14	32	0.35	0.58
Wright's	<6cm	9	0.22	0.44	5	0.2	0.45
	>6cm	3	1	0	7	0.3	0.50

Table 4. Location of ticks

Species		Total number of ticks		Mean number of ticks per skink	
		toes	armpits	toes	armpits
Seychelles	<6cm	22	0	3.14	0
	>6cm	217	70	2.82	0.91
Wright's	<6cm	0	1	0	0.07
	>6cm	6	4	0.6	0.4

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NOTES

The arrowhead vine, *Syngonium podophyllum* Schott (Family Araceae), a potential invader in Seychelles

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There appears to have been no record of the occurrence in Seychelles of *Syngonium podophyllum* Schott (Family Araceae), the so-called arrowhead vine ("patte d'oie" in French) of the foliage plant industry, before it was mentioned by Robertson (1989) in her annotated checklist of the flowering plants of these islands. Robertson found the species growing on Mahé some time between September 1975 and the end of 1981.

By 1987 *S. podophyllum* had become a widespread cultivated "ornamental" in gardens all over Mahé; in 1991 it was found to be growing as an escape near the houses on the eastern side of Frégate; in 1993 some specimens were found growing among coco-de-mer palms in the Vallée de Mai nature reserve on Praslin, and a vase containing shoots of the plant was observed in the guest-house on Silhouette (all personal observations). It is extremely likely that it occurs on La Digue as well.

In Robertson (1989) the specific name of the plant is preceded by a question mark ("*S. ?podophyllum*"), indicating that the author was uncertain of its specific status. Most of the specimens I have examined certainly appear to be *S. podophyllum*, displaying the heterophylly for which it is notorious: young plants have simple arrow-shaped dark green leaves with pale, almost whitish, markings along the major veins; while on mature plants the leaves are entirely green and range from those that consist of three leaflets (a larger central one with a pair of smaller ones at its base) to those with up to eleven leaflets arranged palmately. There are also "intermediate" leaves with three or more lobes that retain the pale markings. Some of the plants examined had slightly different leaves (some were almost heart-shaped, with the pale coloration extending beyond just the main veins) but they were probably cultivars of the same species – which would mean that there have been more than one introduction to Seychelles.

It is now clear that *S. podophyllum* has the potential to become invasive in the

granitic islands of Seychelles. Lush stands covering many dozen square metres occur in escape situations in the vicinity of residential areas at Le Niol, Bel Ombre, Mont Buxton and other parts of Mahé. Preliminary observations suggest it thrives best in conditions of moisture and partial shade. In such situations it grows aggressively, climbing up rocks and trees by means of its "adhesive" adventitious roots, and smothering all other vegetation.

A combination of factors favours the further spread of *S. podophyllum* in Seychelles. It is currently a particularly popular "house" plant, probably not only because of its variegated juvenile leaves but also because it is extremely hardy, cut shoots being able to survive for several months in vases containing only water. Discarded portions are often thrown onto rubbish heaps and on waste ground, and there they root and sprout new shoots readily, displaying a strong capacity to resist desiccation, even in times of drought (pers. obs.). The species is also deliberately cultivated in gardens from cuttings. Wherever it grows, secondary shoots bearing roots may become separated from the mother plant, resulting in vegetative propagation, but the presence of juvenile plants some distance from old stands suggests *S. podophyllum* can also produce viable seed. Certainly it flowers regularly in Seychelles, the inflorescences appearing to be concentrated on shoots creeping up tree-trunks and other supports.

S. podophyllum, a native of tropical America , is one of several species of climbing plants of the family Araceae introduced to Seychelles. One of them, *Epipremnum pinnatum* (L.) Engl. (also known under the synonyms *E. aureum* (Lind. & André) Bunting; *Philodendron nechodomii* Britt.; *Pothos aurea* Lindl. & André; *Rhaphidophora aurea* (Lind. & André) Birdsey; *Scindapsus aureus* (Lindl. & André) Engl.), the "*Philodendron*" of some authors, is already a pestilential invader in parts of the Vallée de Mai on Praslin (Beaver and Chong-Seng 1992). In the United States, the Exotic Pest Plant Council of Florida lists *S. podophyllum* under "Category II", i.e. as one of the "species that have shown a potential to disrupt native plant communities" (EPPC Invasive List Committee 1997). No disruption of native plant communities by the species has yet been observed in Seychelles but its tendency to develop readily into extensive monospecific stands in areas of secondary vegetation next to residential areas does not augur well for natural habitats.

Those plants that have been examined harbour an extremely reduced insect fauna, made up mostly of the ant *Technomyrmex albipes* (Smith, 1861) and the mealy bug *Icerya seychellarum* (Westwood, 1855). A newly-hatched hawkmoth larva, probably *Hippotion eson* (Cramer, 1779) was found on a leaf that bore no sign of insect attack. In captivity the caterpillar refused to feed on *S. podophyllum* and died.

An additional consideration is that *S. podophyllum*, like many other aroids, contains crystals of calcium oxalate (Souder 1963), the ingestion of which may cause irritation of the mucous membranes and swelling of the mouth and tongue in mammals, including humans. Even the outer skin may become irritated if it comes into contact with the cut ends of stems and shredded leaves (André Lucas and Rosemary Mathiot, *pers. comm.*).

In view of the potentially harmful impact that *S. podophyllum* could have on native biodiversity in Seychelles, it is recommended that its rate of spread ("invasiveness") and impact on other species be monitored so that a control programme can be developed if necessary.

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NOTES

Productivity and energetics of giant tortoises on Aldabra, a reappraisal of existing data.

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The wild Aldabran giant tortoises, *Dipsochelys dussumieri* (Gray, 1834), have been studied in considerable detail. Much of the data collected has been combined into models and analyses of ecological and physiological processes. Data on food consumption, digestive efficiency and reproduction have been particularly useful in furthering our understanding of the ecology of this population. However, re-examination of one analysis has revealed a number of short-comings in both the data and the analysis. These are reappraised and new conclusions suggested below.

The energetics of digestion were used to predict productivity patterns on Aldabra by combining curves of size specific assimilation efficiency and respiration to provide a predictive production curve (Hamilton & Coe 1982). The published study found a marked difference between the predictive curve and real production values, with higher than predicted production in both small and large tortoises. These differences were suggested to result from errors in the assumption used to model the predictive curve, namely the linear change in consumption rates with only a crude seasonal aspect and the laboratory origins of the respiration rates.

The origins of the respiration data may affect the precise values but appear to be sufficiently robust to determine a reliable pattern (Hughes *et al.* 1971) which is all that is needed in this instance. In contrast the assimilation curve is derived from statistically non-significant regressions (Hamilton & Coe 1982). These data are insufficient to determine a true curve and more plausible patterns can be proposed.

As the true values of production have been calculated separately (Coe *et al.* 1979) it

is possible to evaluate the error in the assimilation curve. If the assimilation curve is derived from the difference between the actual curves for respiration and production a radically different pattern is obtained. In this case assimilation is high in hatchling, decreasing rapidly in juveniles with the rate of decrease slowing in large animals (Fig. 1). For this to occur hatchling and small juveniles would either have to have adaptations improving digestive efficiency or would be feeding on more easily digested, more nutritious plants than older tortoises.

The suggestion that hatchlings feed on more easily digested and/or more nutritious plants is in accordance with known feeding patterns; small juveniles feed on the herbs in mosaic rock whilst larger tortoises are restricted to the high cellulose containing grasses (Grubb 1971). The rapid decrease in the 2-7kg range apparent in Fig. 1 may be due to small tortoises making the switch from the nutritious mosaic rock diet to the open habitat diet. These tortoises would have straight lengths of approximately 20-30cm and would be expected to be 4-8 years old (Grubb 1971). The holes in mosaic rock that young tortoises feed in support a wide range of herbs and grasses, of which *Boerhavia crispifolia, Evolvulus alsinoides, Hedyotis prolifera, Hypoestes aldabrensis, Lagrezia oligomeroides, Phyllanthus maderaspatensis, Ruellia monanthos* and *Sida pusilla* are the most important in the tortoise diet (Grubb 1971). Chemical composition of Aldabran plants is unknown but confamilial species from the granitic Seychelles have relatively high protein levels (11.3-16.9%) and variable calcium to phosphorus ratios (1.0-4.0) (unpublished data from Acanthaceae and Convolvulaceae). Adult diet is dominated by grasses, data from the granitic islands indicate that these have lower values for protein and calcium:phosphorus (10.9% and 1.7 respectively). This supports the suggestion that the most nutritious diet is largely confined to the mosaic crevices from which the larger tortoises are excluded, giving rise to the productivity patterns described above.

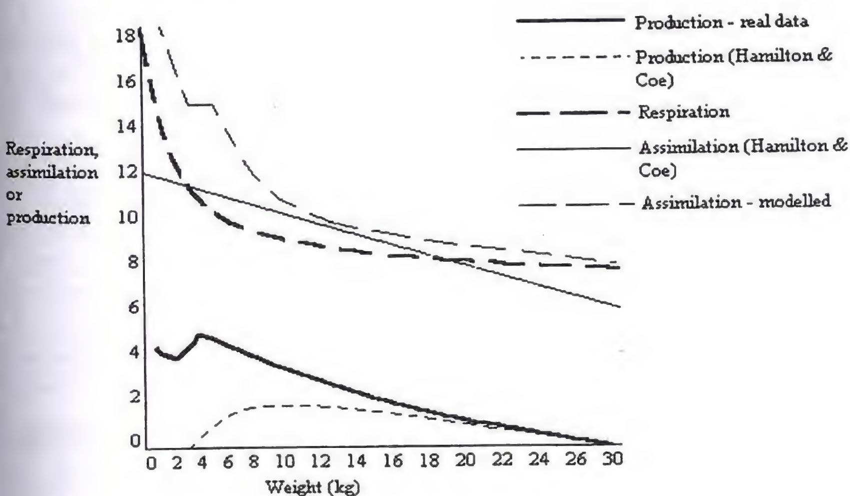

Fig 1. Energetic curves for wild Aldabran tortoises

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NOTES

Vascular wilt in takamaka (*Calophyllum inophyllum*) and the bark beetle *Cryphalus trypanus*

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A recent study of the vascular wilt fungus *Verticillium calophylli* (Wiehe, 1949) (now considered to be in the genus *Leptographium*) infecting takamaka trees *Calophyllum inophyllum* L. in Seychelles identified the bark beetle *Cryphalus trypanus* Sampson, 1914 (Coleoptera: Scolytidae) as a vector of the pathogen (Wainhouse *et al.* 1998).

The beetle breeds in takamaka branches and is abundant in trees infected with vascular wilt, burrowing into leaf petiole scars and cut branches. The vascular wilt fungus was cultured from beetles collected from infected trees, identifying *C. trypanus* as the likely vector of the pathogen in Seychelles (Wainhouse *et al.* 1998).

C. trypanus is endemic to Seychelles (Beaver 1987) and has been recorded from Mahé, Silhouette and Marianne (Sampson 1914). It has previously been recorded breeding only in *Northea hornei* (M.M. Hartog) Pierre (Sampson 1914; Beaver 1987) 300m above sea level.

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The origins of *Isometrus maculatus* and other scorpions on the smaller islands of the western Indian Ocean

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The circumtropical and almost cosmopolitan scorpion *Isometrus maculatus* (Geer, 1777) is generally regarded as a species introduced by man. Its origins are obscure but are assumed to be Oriental (Pocock 1909). It has a very wide distribution, being first recorded from Europe (Linnaeus 1758, as *Scorpio europaeus* prior to its description by Geer in 1777 as *S. maculatus*), then from South America in 1800, Africa (1858) and Asia (1892) (Pocock 1909). Indian Ocean records start from 1868 (Pike 1970a - see below).

In Seychelles *I. maculatus* has been recorded from Mahé (since 1905), Silhouette (1998), Aride (1979), Cousin (1974), Bird (1905) and Denis (1905) in the central islands and from Astove (1905), Cosmoledo (1905) and Aldabra (Takamaka, Ile Esprit and Ile Michel; 1905) in the corraline islands. In the Mascarenes it is known from Round island and Gunner's Quoin. It has been recorded in houses (Mahé, Aride, Cousin), under bark (Silhouette, Round island) or in caves (Silhouette) and is clearly well adapted to dispersal by rafting or as a stow-away in cargo.

Other scorpions on small Indian Ocean islands include the superficially similar *Lychas* (*Archisometrus*) spp. (distinguished by the presence of tibial spurs on legs III and IV) which usually reach 30-60mm rather than the 45-70mm of *I. maculatus*. These are endemic to the islands they inhabit (*L. braueri* (Kraepelin, 1896) on the Seychelles islands of Mahé, Silhouette and Praslin) and *L. serratus* (Pocock, 1890) on Round island, Mauritius. *L. braueri* is extremely rare; it was collected on Praslin in 1894 by A. Brauer (Kraepelin 1896) and on Mahé ("in high jungle") and Silhouette by the Percy Sladen Memorial Expedition in 1905 (Hirst 1913). The only subsequent record is a single specimen from Jardin Marron, Silhouette in 1990 (OUSE 1990). *L. serratus* appears to be extinct, not having been located since 1868. Also present is *Chiromachus ochropus* (Koch, 1838), belonging to a monospecific genus regarded as a Seychelles endemic but recorded from Zanzibar and Round island (Mauritius) (Pocock 1893). The Zanzibar record is supported by 6 specimens in the British Museum (Natural History) and the Round island record by a single specimen presented by H. Barkly. The Barkly material is reliable, being collected by Lt. Col. N. Pike (see below), but the provenance of the Zanzibar specimens is doubtful. There are three puzzling records from Zanzibar; the scorpion, the whip-scorpion *Phrynops scaber* and the Seychelles chameleon *Chamaeleo tigris*. The first two records are found on Seychelles and Round island so could plausibly have reached Zanzibar whilst the chameleon is a Seychelles endemic restricted to Mahé, Silhouette and Praslin islands. All the Zanzibar records are derived from specimens collected by Capt. J.E. Parish in the late 1800s. Thus the Zanzibar records of *Chamaeleo tigris*, *Chiromachus ochropus* and *P. scaber* are almost certainly errors for Seychelles specimens. *C. ochropus* appears to be extinct on Round island. In Seychelles it has been recorded

on Mahé, Praslin, Fregate and Recifs. The only Mahé record is from 1768 (Gerlach 1995), it is occasionally located in the Vallee de Mai on Praslin (P. Matyot *pers. comm.*) and is relatively abundant on Fregate. The status of the Recifs population is unknown.

The Round island (Mauritius) specimens provide some useful information in the collecting notes made by Lt. Col. N. Pike (1870a&b). During his visit in 1868 Pike (1870a) noted that "scorpions and centipedes were plentiful, especially on the palms. The former were quite green, and could scarcely be distinguished from the leaves; though they changed to brown on being put in alcohol. They were about 2 inches in length, of a species I have not seen in Mauritius." This appears to be the same as his collected specimen "No. 7" (Pike 1870b):

"No. 6. Two small scorpions found on the vacoa (*Pandanus Vandermeerschi*) and very plentiful on the broken leaves. They seem entirely different from the Mauritius scorpions, or from specimens I have seen from the adjacent Islands of the E. Indies."

"No. 7 is a very singular specimen I captured on my first visit to Round Island. It was of a bright green just the colour of the Palm (on which) I found it. The creature was very active and defiant, and it was with difficulty I caught him. You will observe the great length of the tail compared with the others; its sting was unfortunately broken off by accident. I think it is rare as I failed to find it on my second visit, and it was whilst diligently searching for one I found the large.

"No. 8. This formidable and ugly looking animal is not uncommon in the crevices of rocks and under the stones round the summit of the mountain. It is most pugnacious and when headed off from its retreat will show fight by raising the palpi, and clapping them together making a clicking noise like a crab.

"This Scorpion measures 4¾ inches from head to tail, and the palpi 3¾ inches making a total length of 8½ inches, the latter are 1¾ in circumferences. The body and legs are brown and the palpi black. I tired but unsuccessfully to capture another that was running off very fast over the stones with what I took to be *Scincus Boutonii* in its claws." (Pike 1870b)

Pike's specimen "No. 7" is the damaged holotype of *L. serratus*, and the only known specimen of this species. "No. 6" is *I. maculatus* and No. 8. To *Chiromachus ochropus*. From these notes it is apparent that *I. maculatus* was abundant on Round island, both this and *L. serratus* were largely arboreal. In contrast the large *C. ochropus* was a terrestrial predator of small vertebrates and probably large invertebrates (Pike noted large beetles and phasmids as being present; Pike 1870a&b). The devastation of Round island by erosion, following overgrazing by rabbits and goats in the 1900s resulted in the loss of *L. serratus* and *C. ochropus*. In 1948 no scorpions were located (Vinson 1949) although *I. maculatus* is still present and has been recorded on several occasions (1975 - Bullock & North 1976, 1982 - Bullock *et al.* 1983, 1993 - P. Daszak *pers. comm.*). It was also recorded on Gunner's Quoin in 1982 (Bullock *et al.* 1983).

If introduced then presumably on the only cargo to be unloaded onto Round island prior to 1868 - rabbits or goats (the former at an unknown date before 1844 and the latter between by 1868; Cheke 1987) and its date of introduction could be assumed to be in the early 1800s, significantly earlier than the first Seychelles record.

There seems to be little doubt that the Round island *Lychas serratus* is extinct. Pike

(1870b) noted it as being conspicuous and the vegetation it was recorded on was largely destroyed in the late 1800s. The status of the Seychelles species is difficult to determine, it is clearly very rare but the reasons for its rarity and its true distribution remain obscure. The observation of a living specimen is the single recent specimen (Silhouette 1990) which was killed and eaten by ants (*Technomyrmex albipes*) (P. Matyot *pers. comm.*). Research into the ecology of this species is a high priority. It has previously been classified as endangered (Gerlach 1997).

Chiromachus ochropus also appears to be extinct on Round island, again, habitat destruction would seem to be the most likely cause. The species remains locally abundant in Seychelles, particularly on the island of Fregate. On Mahé it appears to be extinct, not having been encountered for 231 years. On Praslin occasional specimens have been encountered in the Vallée de Mai (one of these was kept in captivity and fed on cockroaches - P. Matyot *pers. comm.*). The status of the Recifs population is unknown. Fregate supported large numbers of the species although the large population of brown rats (*Rattus norvegicus*) which invaded the island in 1995 have been suggested to be a potential threat (Gerlach 1997). There are recent reports of apparent declines in abundance and scarcity of large adults (M. Nicoll & K. Murray *pers. comm.*) although quantified data are lacking. The species has previously been regarded as vulnerable (Gerlach 1997), recent suggested declines may indicate that it is now endangered (A2e and B1&2e in the IUCN Red List criteria). Research and conservation measures have been planned as a matter of urgency.

In conclusion, the Seychelles and Mascarene islands are known to be inhabited by two native scorpion genera, *Chiromachus* and *Lychas*, currently represented by highly endangered relictual populations in Seychelles only. *Isometrus maculatus* is probably introduced but this cannot be known with certainty. It may fill the ecological niche left by the extinction of *Lychas serratus* on Round island.

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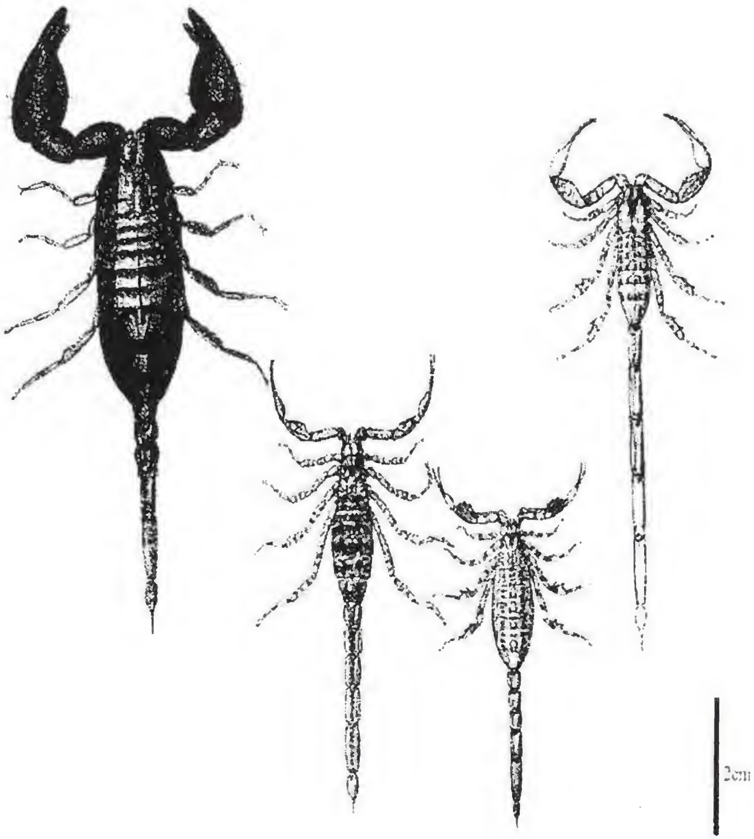

Chiromachus ochropus *Isometrus maculatus* *Lychas braueri* *Lychas serratus*

On the first recorded observations of egg-laying in *Dipsochelys arnoldi*

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The rediscovery of Seychelles giant tortoises in 1997 (Gerlach 1998; Gerlach & Canning 1998) led to the establishment of a captive breeding programme for both surviving Seychelles species *Dipsochelys hololissa* (Günther, 1877) and *D. arnoldi* Bour, 1982 (Gerlach 1998). This was established in July 1997 using animals purchased from a variety of captive locations in Seychelles. Of the two species *D. arnoldi* was initially represented by a single pair, two further males and a female being added subsequently. The first apparently successful matings were observed in 1999 and on 8th July 1999 eggs were laid by 'Clio', the original female *D. arnoldi*. Although it is presumed that all the living D. arnoldi were captive bred the notes made on the 8th July are the first recorded observations of egg-laying in captive *D. arnoldi* and may be the first reproduction in this species for some 75 years. As this is a significant event and there is no literature describing breeding in *D. arnoldi* careful notes were made and these are summarised below.

Mating

Although mating had been observed since 7th August 1997 no successful matings were observed until 1999. The female appeared to be un-cooperative, either sitting down when mounted or walking away. The male also seemed to be inexperienced and rarely positioned himself appropriately. On the few occasions where the male pursued the female and succeeded in mounting her she showed a greater degree of cooperation, stopping moving and raising the rear of her shell. This suggests that the female was using some degree of mate-choice by requiring a pursuit before being cooperative.

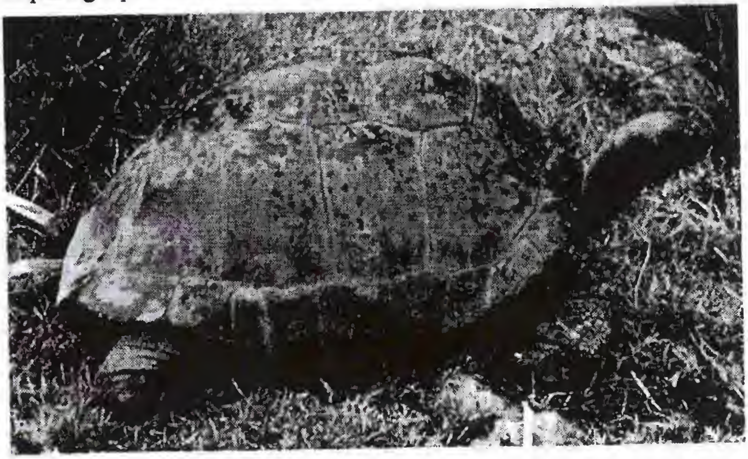

Fig. 1. 'Clio' - adult female *Dipsochelys arnoldi*

In July 1998 the female started showing signs of restlesness, pacing the enclosure, climbing and trying to climb out of the enclosure. The male (and two smaller males that were added in September 1997) was moved to a different enclosure in the hope that these behaviours were a prelude to nesting. By the end of the year no eggs had been laid and she returned to the males.

Mating was recorded from 11th January 1999. Behaviour patterns in the female did not differ appreciably from the previous year (cooperative matings represented 16% of attempts compared with 27% in the same time period of the previous year). Of the 7 cooperative mating attempts 2 (29%) appeared to be successful. Successful mating was observed on 16th January, at 15:00-15:15. The first abnormal behaviour was noted on 28th January when she was found attempting to mate with another female. The second possibly successful mating occurred on the 1st May, given the abnormal behaviour noted above prior to 1st May it is probable that fertilization occurred as a result of the 16th January mating.

Pre-nesting behaviour

The female's behaviour appeared to be normal (activity mainly restricted to feeding) until 28th January when she was recorded mounting the other female. This was also observed on 28th February, 15th June and 20th June, the dates suggesting an increasing frequency of this behaviour although other incidents may have been overlooked. On 28th April she was observed sitting on raised ground, this followed by increasing restlessness from 18th June. Restlessness manifested itself as extended periods of perimeter walking, climbing onto raised ground and attempting to climb over the fence. This was constant from the 21st June.

An increase in appetite was apparent in early June, from 22nd June feeding was rarely observed. On 25th June she was removed to a separate and empty enclosure. Following this isolation 2 days were spent resting in the wallow and then pacing and climbing behaviour was resumed on 29th June and continued (with the exception of 30th June when behaviour was apparently normal).

The first nesting attempt occurred on 3rd July when she was observed tearing up grass with her front legs. This was observed at 17:25 but ceased shortly afterwards. From the 4th-8th July she made regular visits to the abandoned hole and other sandy scrapes, including crab holes. In all cases she would stop and sit next to, or in the scrape, sniffing the ground carefully and watching movements in surrounding areas.

During the nights of 5th-6th July she slept in the water, on the 7th July she slept on land but was notably restless and turned around frequently.

Behaviour on the 8th July included perimeter walking in the morning, at 7:00 she was observed tearing the grass with her front legs. She investigated the scrape thus created but left it shortly afterwards. She slept from late morning through the afternoon, waking in the late afternoon to walk around. At 17:15 she returned to the scrape and nesting started from 17:23.

Nesting behaviour

Time	
17:15	investigating scrape created in morning
17:23	tearing grass with front legs, expanding open circle from 30cm to 60cm diameter
17:38	move forward over hole, sniff ground then lift shell and dig with right hind leg
17:39	continue digging with leg in hole, scraping forwards and back, then alternate leg
17:40	urinate in hole
18:02	urinate
18:19	back of shell sunk 4cm into hole
18:41	shell sunk into hole 10cm
20:00	25cm deep, left side sloping, right steep
20:50	30cm deep, straight sided
20:58	starting to dig bell pit, scraping forwards towards head, tail also pointing forwards
21:00	small quantity of urine
21:07	32cm deep, 21cm wide, bell 10cm deep, 6 wide
21:28	urinated
21:25	spoil falling into hole
21:37	35cm deep
21:52	urinate
22:14	small quantity of mucus leaking out of cloaca
22:19	40cm deep
22:27	mucus
23:09	pressing down spoil in hole but still scraping as well
23:12	having difficulty reaching spoil
23:14	stop, sank down, tail down
23:15	mucus string
23:16	1st egg, cloaca at edge of hole, egg crushed between tail and ground
23:17	movement of right hind foot to cover hole, spoil knocked in
23:18	3 eggs together, preceded by mucus
23:18	movement of right hind foot to cover hole, more spoil knocked in
23:21	1 egg, preceded by mucus
23:23	2 eggs, preceded by mucus, not simultaneous but close
23:38	3 eggs, preceded by mucus, not simultaneous but close
23:40-53	breathing heavily, shell visibly moving 4mm due to breathing movement
23:54	1 egg preceded by few drops of blood, oval egg
23:55	1 egg with small quantity of blood in mucus, oval egg
23:56	fill hole, pushing spoil back in by use of lower leg (from knee), spread over egg chamber with claws, gentle side-to-side sweeping, alternating legs
24:35	hole 2/3 filled
24:36-07:00	[not observed]
07:00	still trampling area, tearing grass at edges
07:30	left nest site

Fig. 2. The clutch of *Dipsochelys arnoldi* eggs (Photo: R. Gerlach).

Throughout the nesting digging continued at the same rate and without pause. Each leg was used for a mean of 37.8±2.07seconds (N=42). Timing of digging activity at 17:39, 18:02 and 22:06 suggested an increasing digging rate (42.1±4.06, 37.9±3.25 and 32.8±3.32 seconds respectively) but these differences are not significant (paired sample t-tests $t>1.78$, $P>0.05$ for all comparisons). The use of the alternate leg action resulted in the fresh spoil extracted from the hole being compacted next to the hole by the resting leg. This reduced the amount of spoil falling back into the hole. Each scoop of the right foot (lacking 3 claws) was estimated to be removing approximately $10cm^3$ of soil, the left foot (lacking 4 claws) removed less than $5cm^3$.

Egg data are summarised in Table 1.

Table 1. Egg weights and measurements

(n=11)	Mean	SE
Weight (g)	80.91	2.11
Shortest dimension (mm)	48.66	0.27
Longest dimension (mm)	50.38	0.68

Table 2. Nest temperature variation

Location	Min. (°C)	Max. (°C)
surface	25	40
10cm	25	30
20cm	27	29
30cm	29	29
40cm	29	29

Nest site characteristics

The nest was positioned in the middle of an open area of *Stenotaphrum dimidiatum* grass growing on coral sand in full sun for 8:05 hours (08:10-16:15), temperature variation is given in Table 2. Nest site temperatures taken on 4th August were found to be a constant 28 °C at 30cm below the surface. The nest chamber was positioned at 30-40cm below the surface.

Behaviour following laying

In the days following nesting, activity was much reduced. On 9th-10th July she fed from 06:30-08:00 and then slept for the rest of the day. On 11th July perimeter walking was resumed after feeding, occupying the hour between 08:00-09:00. The duration of perimeter walking increased each day and included a resumption of climbing and ground sniffing from 12th July. Feeding throughout this time was limited to the early hours when small quantities were consumed, occasional bouts of grazing lasting 1-2 minutes were noted at other times. On 15th July activity lasted until 11:30am.

Egg incubation

The eggs were incubated in the range of 29-32°C. At the time of writing incubation continues and it is hoped that hatching may start in October 1999, this will be reported on in due course.

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